State of California - The Resources Agency
ARNOLD SCHWARZENEGGER, Governor

DEPARTMENT OF FISH AND GAME
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June 6, 2008

Ms. Pamela C. Creedon, Executive Officer
Regional Water Quality Control Board
11020 Sun Center Drive #200
Rancho Cordova, California 95670-6114

Dear Ms. Creedon:

Subject: Response to Comments San Joaquin River Group Authority's Written Comments to Proposal by Central Valley Regional Water Quality Control Board to List the San Joaquin, Tuolumne, Merced and Stanislaus Rivers as Impaired Bodies of Water for Temperature Pursuant to Section 303(d).

Thank you for this opportunity for the Department to respond to comments you have received from the San Joaquin River Group Authority (SJRGA) representatives (attached).

If your staff needs the literature references in our scientist response, please encourage them to work with Dr. Andy Gordus, Staff Environmental Scientist (Regional Water Quality Biologist), on my staff at the address or telephone number provided on this letterhead.

Sincerely,

Dean Marston for

W. E. Loudermilk
Regional Manager

Attachment

cc: On Page Two

received
6/9/08
GENERAL MANAGER

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Mr. Thomas Howard
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ATTACHMENT

Department Of Fish And Game Response to Comments San Joaquin River Group Authority's Written Comments to Proposal by Central Valley Regional Water Quality Control Board to List the San Joaquin, Tuolumne, Merced and Stanislaus Rivers as Impaired Bodies of Water for Temperature Pursuant to Section 303(d).

Overview

The population crash of the Chinook salmon along the Pacific coast has been a common subject in the recent news. The decline has closed all commercial and sportfishing along the Pacific coast, resulting in significant economic loss to the communities and industries that depend on this natural resource. Many the articles emphasize ocean conditions as a cause to this decline. The media interviewed Federal biologists at NOAA whose primary jurisdiction is the marine environment. However, the lack of successful reproduction in California rivers is a major contributor to this population crash. This is clearly the case for anadromous fish in the San Joaquin River system. Dr. Peter Moyle at U.C. Davis presented a commentary identifying the many factors that led to this historic decline (Appendix A). He explained that the ocean conditions is one of many variables that have impacted the recent crash, but they are superimposed on a population that has been declining across the decades as a result of human caused declining river and delta conditions.

The San Joaquin River salmon populations (adult escapement) have substantially declined since 2001 and last year's decline in ocean conditions only accelerated an already steady decline in adult escapement to San Joaquin River tributaries. In addition, concurrent with the adult decline was the sharp decline in spring pulse flow magnitude and duration during the brood production years for which San Joaquin River tributaries salmon escapement abundance also sharply declined. During the fall 2006, the Merced River Fish Hatchery spawned only 36 female salmon out of a total of 79 fish trapped. This group of returning fish were mainly off springs of the 2003 year class from which the Merced Hatchery spawned 248 females from a total of 549 fish trapped.

Historically, the San Joaquin River basin had spring-run, late summer-run, fall-run, and winter-run Chinook salmon populations. In reality, there were salmon in the San Joaquin River Basin on a year-round basis, plus steelhead were also present year-round. This was the case prior to the dams, and as old dams gave way to new dams and California's demand for water use out of rivers increased, the changes in river and Delta habitats has placed higher water quality threats on San Joaquin anadromous fish. Today, three of the four "runs" have been extirpated in the basin with only the fall-runs of salmon and small steel head runs on the Merced, Tuolumne, and Stanislaus Rivers remain. The California Department of Fish and Game (Department), as the fish and wildlife trustee agency, is responsible to protect and maintain these last remaining salmon and steelhead populations in the San Joaquin River Basin.

If one reviews a historic distribution map of the Chinook salmon and steelhead range, their primary water source was from snow melt streams and rivers. Snow melts at the same temperature in California, as it does in the States of Washington and Oregon. The laws of physics do not change based on location. Another major source of cold water was from ground water seeps or springs. Cool water temperatures were also maintained by shade produced from trees and vegetation within the riparian zones. Salmon and steelhead co-evolved under these natural environmental conditions. Today, the much cold snow melt water is blocked and stoned by dams and ground water pumping within the San Joaquin River Basin has diminished surface flows to the rivers. Fish migration into the cool upper watersheds is blocked. So much ground water pumping has occurred across the decades in the San Joaquin Valley that it has resulted in lower water table levels and ground subsidence in many areas. Today, natural water flow regimes, which these fish evolved with no longer exist resulting in the extirpation of three salmon races and the serious decline of the last remaining fall-run Chinook salmon population to the point where listing as an endangered species maybe now be warranted (Mesick 2008) (Appendix B). The steelhead population is already listed as a threatened species in the Central Valley ecologically significant unit under the Federal Endangered Species Act.

Response

We have reviewed the San Joaquin River Group Authority (SJRGA) comment report and present our comments and clarifications. The (SJRGA) comments appear to emphasize "tolerance" temperatures, which is the survival of a group of individuals across a short time line. The Department emphasis is the reproduction and recruitment success of an entire population across each generation in recognition of the evolution and importance of the multi-year class life history strategy of salmon and steelhead. The Department proposal emphasizes Chinook salmon adult migration, egg incubation, smoltification, smolt migration, and steelhead summer rearing temperatures.

Pages 19 to 20. Most of the water temperature literature for fish emphasizes mortality as the end point. Little to no research has been conducted on how sub-lethal temperatures affect fish physiology, reproduction, and recruitment. The SJRGA comments include statements that there is very little pre-spawning mortality. This may be true; however, our purpose for the proposed 303 (d) listing is to protect egg viability before, during and after spawning throughout that life stage.

Their comments refer to the CDFG 1987 report for temperatures. We now have 21 years of additional information that allows us to refine temperature protections for the sustainability of native fish populations.

They suggest that San Joaquin River Basin anadromous fish have adapted to higher temperatures, yet do not demonstrate that these fish co-evolved under a warm water temperature regime. In addition, these fish did not co-evolve under today's altered water management conditions. No evidence exists to show that San Joaquin River Basin salmon/steelhead have higher temperature resistance than northern stocks in the Central Valley or elsewhere. It is assumed that because fish survive in these warmer waters, under today's water management conditions, and they happened to live in the most southern range, that by default these fish in the San Joaquin basin are pre-adapted to warm water temperatures. This premise is based on antidotal comments made by opinions of a number of individuals across time. Yet, no hard scientific evidence supports these opinions. Yet, the genetics evidence in the Central Valley supports a "meta population" conclusion wherein all fall-run and all steelhead in the Central Valley rivers are a common stock. These fish have common lineage and tolerances yet, are subjected to more egregious water temperature in the San Joaquin Basin. One reason why San Joaquin River stocks are facing severe declines and possibly extirpated is because they can not successfully reproduce in elevated (warm) temperature regimes in key river reaches.

<u>Page 21.</u> The SJRGA emphasizes growth temperatures including the statement that Chinook salmon transform into smolts in the wild in excess of 19°C without citing a reference. Marine and Cech (2004) completed a study to determine the effects of temperatures on growth, smoltification, and predator avoidance for juvenile Chinook salmon. Their rearing temperatures were 13-16°C, 17-20°C and 21-24°C. They concluded that Chinook salmon can survive and grow at temperatures up to 24°C, but juveniles reared in the two higher temperature ranges experienced impaired smoltification, and increased predator vulnerability compared to the coolest temperature range. Juveniles reared in the highest temperature range had decreased growth rates compared to the two lower temperature ranges. In addition, impaired smoltification and decreased growth rates result in reduced seawater survival and reduced population abundance. Thus, while they "can grow" in warmer water, it does not appear to be a viable option for sustaining healthy populations.

The SJRGA quoted McMahon (2006) as follows, "The applicability of thermal criteria derived from the laboratory has long been debated, and unfortunately, there has been no confirmatory lab or field data for growth vs. temperature relationship for any of the listed species in the Central Valley to assess if laboratory results are transferable to these stocks (Myrick and Cech 2004)." In the next sentence McMahon (2006) adds this clarification sentence, "However, the target levels (referring to 15.5°C for juvenile salmon rearing in the beginning of his paragraph) do seem to be reasonable targets for species protection given that recent studies suggest that temperatures near optimum growth in a laboratory setting likely frame the upper limits of suitable temperatures for salmonids in nature (McCullough 1999; Selong et al. 2001)."

Myrick and Cech (2005) conducted a study to determine temperature effects on growth, food conversion, and thermal tolerance of Nimbus (American River)-strain steelhead to improve fish rearing and hatchery management. They held juvenile steelhead at 11°C, 15°C and 19°C. Fish reared at 19°C did have increased growth rates compared to the two lower temperatures, which would decrease retention time in the hatchery and feed consumption, thus saving operation costs. The authors also emphasized that although increased growth in hatchery conditions occurred up to 19°C, juvenile steelhead require prolonged cooler temperatures (11°C) for successful smoltification.

Myrick and Cech (2005) cited Wurstbaugh and Davis (1977) who reported that steelhead maximum growth occurred at 16.4°C, however Wurtsbaugh and Davis (1977) (as stated by Myrick and Cech) further stated that optimal growth temperature declined as the ration level decreased from satiation to 60-50% of satiation. Fish in the wild have less available food rations compared to fish raised in a controlled food-rich laboratory or hatchery environment.

Moyle (2005) appears to be a rebuttal to Dr. Chuck Hanson testimony for Chinook salmon juvenile rearing temperature. It is interesting to note that Dr. Hanson's 16°C seven day average of the daily maximum is similar to the Department's rearing temperature presented in Table 1 of our proposal. Dr. Moyle rebuttal continues to point out that it is common to observe salmon survival in valley streams at higher temperatures under "today's" conditions. He fails to recognize that salmon are forced to live in the lower remaining one-third of their original range, under artificial conditions (below dams), and have no other habitat to occupy. Historically, anadromous fish would migrate or rear further upstream to cooler temperatures in the foothills and mountains. Today, they are blocked by dams and are forced to survive higher temperature habitats. Dr. Moyle further discusses survival of individuals, but provides no information as to the reproductive success and recruitment of these populations of fish across many generations, while these populations continue to decline. He further assumes cool water exists from ground water seeps and that temperatures will cool enough at night. If this really occurred in this basin below the dams, we would see it in the water temperature monitoring data either by 1) substantially cooler temperatures at night or 2) reduced warming as water moves downstream. Neither of these occurs. As previously stated, ground water pumping in the valley has resulted in lower water tables and ground subsidence.

Page 22. Williams et al. (2007) does quote Ron Yoshiyama as a personal communication on page 5 of their report. This information was based on an 1875 California Fish Commission report. Salmon were never successfully introduced to the southeastern states. Furthermore, Mr. Yoshiyama statement states that salmon tolerate and survive temperatures up to 80°F (26.7°C), but he does not state whether fish at these temperatures would be highly successful in reproducing or recruitment. Further, in Williams et al. (2007) paragraph where Mr. Yoshiyama is quoted, they stated winter-run Chinook salmon eggs and alevins have complete mortality when water temperatures reach 17.4°C. In addition, the States of Wisconsin and Michigan have a very viable Coho salmon, Chinook salmon and steelhead fisheries in Lake Michigan. Lake Michigan water temperatures are cool enough for the growth and survival of these three species, however, none of these fish reproduce in the surrounding streams because the waters get too hot for reproduction success. As such, these species are captured in the streams, spawned and raised in hatcheries to maintain the fisheries.

The CalFed (1999), Spina (2007) and Myrick and Cech (2001) referred statements again emphasizes survival of individuals, but does not indicate reproductive success and recruitment for these populations that continue to decline. Spina (2007) stated that rainbow trout in their study streams had no where else to go to seek cooler water temperatures. Myrick and Cech (2001) stated fish can acclimate and survive for short periods in higher preferred water temperatures. None of these studies did any follow-up work to determine if these same fish could successfully reproduce and recruit new individuals into the population.

Page 23. The SJRGA stated that Titus (2007) reported successful steelhead rearing in the lower American River at up to 18°C daily average based on growth rates, condition factor and absence of disease. However, this is incorrect. Titus did observe disease in these fish. Fish exposed to temperatures from 18°C to 21°C had intestinal bacterial infections and prolapsed anus. Nearly fifty percent of the fish observed had these clinical signs. Fish exposed to temperatures below 18°C, had a very low bacterial infection frequency. He further states "the conceptual framework demonstrates the significance of 18°C as an *upper thermal limit* (*emphasis added*) for juvenile American River steelhead." In his presentation he states that the ***mean*** daily temperature standard above 65°F (18.3°C) is not biologically defensible to protect steelhead and post-release (fish captured with hook and line and released) mortality increase substantially above 64°F (17.7°C). Essentially, 64-65°F (17.7 to 18.3°C) appears to be a critical chronic exposure threshold, which, a high level of negative effects were observed: mortality from hooking stress increases sharply, bacterial infection was observed, and ultimately death at around 75°F (23.8°C). Secondary effects are likely as well, especially in predator-rich systems like Central Valley rivers. As thermal optima for steelhead/rainbow trout are exceeded at temperatures above 64-65°F, major predators like pikeminnow, striped bass, and black bass are just entering their thermal optima. So, as cold water fish become stressed at temperatures above 64°F, salmon and trout become more vulnerable to predation and habitat conditions favorable to increasing predator populations in key river reaches occurs.

Page 24. The SJRGA report presented "computed natural" flows stating the lowest flows occur in September. With the existence of dams migration to cooler habitats is blocked and natural flows no longer occur. They provided September unimpaired flows values from 1922 to 1992. However, unimpaired is not defined, especially when all the rivers have multiple dams present. All the low flow values presented did not indicate if dams were present and holding water back or was based on controlled releases during those years.

Page 25. Hallock et al. (1970) documented transmitter tagged Chinook salmon "holing" up in the Delta for almost two months before migrating upstream into the San Joaquin River. They observed low dissolved oxygen and high temperature barrier delayed the upstream migration of fish on the San Joaquin River. Their migration research study also discovered salmon will begin migration up the San Joaquin River once dissolved oxygen is above 5 ppm and water temperatures were at or below 65°F (18.3°C).

As presented in Tables 3, 4, 5 and 6 of the Department's 303 (d) proposal, after adult fish enter San Francisco Bay and estuary, anadromous fish migrate up to 133 miles, 137 miles, and 172 miles to reach the Goodwin Dam (Stanislaus River), La Grange Dam (Tuolumne River), and Crocker-Huffman Dam (Merced River), respectively. The Stanislaus River counting weir is at river mile 33, as such, fish have to migrate 108 miles from the Sacramento River and San Joaquin confluence in the Delta. The Merced River Hatchery is at the Crocker-Huffman Dam. Although not all adult fish will migrate up to the river barriers (dams), this information provides a perspective that the fish are present in the San Joaquin River Basin well before they are physically observed. These fish simply do not jump out of the Pacific Ocean and land at a particular observation point. They must annually migrate long distances across time, as well as confront barriers (i.e. low oxygen and high water temperatures in the Delta and low river flows), to reach their spawning grounds.

The Turlock Irrigation District has documented the first observance of adult salmon near La Grange Dam as early as September 5 (Appendix C). Other September dates included the 10th, 16th, 17th, 18th, 22nd, 24th, and 26th. This observation location is near the LaGrange Dam at mile point 52. As such, these fish had to migrate a total of 137 miles from the confluence of the Sacramento River in the Delta indicating salmon were present in the San Joaquin River system as early as August. In addition, river waters need to be "primed" well before the fish arrive to serve as an attractant to their natal spawning grounds.

The Department does not have the sole discretion to determine when the Head of the Old River Barrier is installed and operated. This is negotiated between the U.S. Fish and Wildlife Service (USFWS), California Department of Water Resources, a Reclamation District, landowners and other stakeholders regulatory. Permit timing and the status or impacts to the other salmon races Delta smelt and soon longfin smelt are factors as well.

Again, the Department does not have the sole discretion to determine fall attraction flow schedules. This is based on a negotiated agreement between a number of stakeholders and water availability, and is *not solely* based on the biological needs of fall migrating salmon.

<u>Page 26.</u> The arrival of fish at the Merced River Hatchery triggers our management approach to begin our hatchery operation to spawn fish and to begin stream surveys. It is not an indication when fish began to migrate up the San Joaquin River Basin. It is an indication when the fish arrived at the farthest most reach of the Merced River.

The Department permitted operation of Stanislaus River weir to begin in 2003. It is operated over a range of flow schedules acress water year types. The years 2003 and 2004 were below normal and dry water years, respectively (Appendix D), years 2005 and 2006 were wet years and 2007 was a critical dry year. They indicated 2006 water temperatures were cooler than other years. However, Figure 5 shows water temperatures downstream on the river system were well above 18°C creating a potential temperature barrier well before the confluence of the Stanislaus River; in addition, they do not provide dissolved oxygen conditions during these same time periods. Figure 5 verifies our reasoning that water temperatures are too warm for migrating salmon and creates a potential migration barrier and/or a delay of upstream movement into the San Joaquin River Basin.

The Department's temperature management strategy for the protection of adult **migrating** Chinook salmon emphasis is from September through October. The Department concurs that adults continue to migrate into December; however, our protection emphasis for egg incubation begins October 1, because if the egg/incubation goals are met (13°C), by default the adult migration goals (18°C) will be met. Our desire is to ensure protection in the entire reaches during the entire migratory season generally in most years, including early migrants, and not just the peak periods. As previously stated, there are a number of "barriers" that delay migration of the remaining populations (fall-run Chinook and steelhead).

<u>Page 27.</u> Department operations and timing depend on a number of factors including funding, staff availability, work loads and management priorities.

<u>Page 28.</u> The SJRGA suggests that the adult timing is October 1 to December 20. We concur that fish migrate through December, however, we do not concur with simply writing off the early or late fall migrants as this serves to further selective pressure of an already stressed population. As previously, stated salmon were once in the San Joaquin River Basin on a year-round basis and flows, temperature and dissolved oxygen conditions impact fish migration during the early season, thus delaying migration.

<u>Pages 28 to 29.</u> It is common sense that fish need water and high water quality to reproduce and maintain sustainable populations across generations. Our proposal emphasizes the temperature protection for the last remaining reach (downstream from the dams), for all life stages, for the last remaining genetic population of Chinook salmon and steelhead in the San Joaquin River Basin.

<u>Page 29.</u> As previously stated salmon have to travel172 miles from the Sacramento River confluence in the Delta to reach the Merced Hatchery which is at River Mile 58. Clearly, these salmon are in the San Joaquin River system well before they arrive at the hatchery at the terminus of this run. Migration delays due to temperature and dissolved oxygen barriers downstream remain an important issue for these stocks.

<u>Page 31.</u> The SJRGA stated that the last remaining 3% of the outgoing juveniles are not important. We do not concur with this philosophy. Flow operations were determined through negotiation of many stakeholders and issues, and *not solely*

based on the biological needs of the fish. In addition, monitoring terminated before all the juveniles out migrated, thus the total count and timing is underestimated.

The SJRGA reported that there was no purpose going back to 1973, and also criticized not going back further in the years for other sections of our report. They state that "it is not represented under current basin operations." It has become obvious that certain current water management operations in the San Joaquin River Basin are not beneficial to salmon and steelhead. These populations have continued a steady decline across decades and have experienced precipitations crashed in the last two years.

Newman (2008) (Appendix E) smolt survival evaluation in the reach leading into the South Delta (e.g. Durham Ferry to Mossdale) indicates that smolt survival decreased substantially with increasing water temperatures.

Page 31 to 32. All FERC settlements are based on negotiations with a number of agencies, stakeholders and special interest groups and are not entirely based on the biological needs of the fish. It should be noted that the Department is a large state agency, with many staff who work under a heavy workload, who negotiate with many individual project proponents and other stakeholders that results in a variety of negotiated settlements on a project-by-project basis.

Page 32. Concerns with how the criteria are applied

I. CDFG's use of criteria for smoltification is inconsistent between locations. Specifically, the CDFG assessment uses 15°C as the criteria for the tributaries and 18°C in the San Joaquin River.

In EPA's Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards, the 18°C standard is for protection of the juvenile out-migration corridor while the 15°C standard is for protection of smolt rearing habitat. The main stem San Joaquin River provides primarily out-migrating corridor habitat (18°C) for smolts while the east-side tributaries primarily provide rearing habitat (15°C). As such, there is no inconsistency in Department's smolt protection criteria.

II. CDFG substituted data from distant locations when data was missing for a particular station. For example in the assessment of Tuolumne River adult upstream migration, data are not available from Shiloh (RM 4) during 2002. Instead, data from Waterford RM 32) is substituted to represent conditions near the confluence. This issue was found by chance while perusing the formulas and hyperlinks used in CDFG's Excel spreadsheets. Obviously the data was not presented properly which casts doubt on the accuracy of the rest of the analysis, especially in light of the other factors identified during this preliminary review.

Hyperlinks were not used in the Excel spreadsheets. Empirical (e.g. measured) water temperature data exists at three river mile locations (e.g. river mile's 32, 42, and 52) for the 2002 Tuolumne River Adult upstream migration. Appendix F presents the template that the Department used to evaluate 2002 adult upstream migration temperatures in the Tuolumne River. This example template is the same type that was used in all years and for the Tuolumne, Merced, Stanislaus, and San Joaquin Rivers. Appendix F outlines values from empirical data at river mile's 32, 42, and 52 (e.g. seven day weekly average of empirically measured daily maximum water temperatures). Water temperature values were calculated, by interpolation between river mile's 52 and 42 (+0.9°C/mile) and between river mile's 42 and 32 (+0.3°C/mile), to calculate increasing water temperature on a per mile of river basis. No empirical data exist between river mile 0 and 31, so river mile 32 temperature value was to reflect river mile's 0 to 31. Although river water temperatures do increase as it flows downstream, for analytical purposes we ***assumed*** no additional warming occurred between river mile 32 and the confluence. Thus, the temperature analysis in the Departments document/testimony for this reach of the river (river mile 31 to the confluence) was **conservatively** estimated, even though water temperatures do increase as the water flows downstream. Further refinement may be possible yet, we suspect the resulting conclusion will remain essentially the same.

Based on years where empirical data exists for sites near river mile's 32 and 0 (e.g. immediately upstream of the confluence) the rise in temperature can be dramatic. Appendix G shows an example of the warming that occurs between river mile 37 and river mile 4 in 2003. In 2003 there was a 5ºC (9ºF) elevation in temperature between river mile's 37 and river mile 4. If empirical data existed for all years at river mile's 32 and river mile 0 the temperature impairment analysis would be worse in some years than what was identified in the Departments conservative analytical approach using river mile 32 value for the remaining reach to the confluence. As such, there was no misrepresentation of data in the Department's analysis, neither is there cause to doubt Department's analytical results.

III. The sub-set of available data used in CDFG's assessment focuses on a string of several dry years and the periods do not generally represent the distribution of water year types. CDFG's decision to only use some of the available data is clearly another bias that was purposefully introduced. Additional data has been provided to CDFG previously and is available from monitoring efforts conducted by TID/MID on the Tuolumne River since 1986 and by Tri-Dam on the Stanislaus River since 1998.

The San Joaquin Valley Water Year Hydrologic Classification includes the following year types and water year index (Appendix D):

Year Type:	Water Year Index:	Year
Wet	Equal to or greater than 3.8	1998, 2005, 2006
Above Normal	Greater than 3.1, and less than 3.8	1999, 2000
Below Normal	Greater than 2.5, and equal to or less than 3.1	2003
Dry	Greater than 2.1, and equal to or less than 2.5	2001, 2002, 2004
Critical	Equal to or less than 2.1	

As shown above, the Department's representation of analytical years included years within each water year type except for Critically Dry years. Appendix H shows the flow range conditions, represented as water year types by percent historical Exceedence, that were covered in Department's analysis. As shown in Appendix H, the wetter range of conditions has been included in the Department's assessment for the east-side tributaries. For Vernalis, the entire range of flow conditions was included in the Department's assessment (Appendix I). While the critically dry conditions have not been assessed for the east-side tributaries it is anticipated that water temperatures would exceed those values observed during Dry year type conditions by virtue of 1) lower instream flow levels and 2) the strong relationship between instream flow levels and water temperature.

IV. The ability of individual salmon to survive, tolerate, or thrive at a particular temperature is the result of a combination of recent thermal history (i.e., acclimation), availability of thermal refuges, length of exposure time, daily temperature fluctuations, genetic background, life stage, interactions with other individuals and species, food availability, and stress from other factors (e.g., pollution). CDFG's analysis ignores 8 out of the 9 factors.

Fish are endothermic (e.g. physiologically controlled by ambient water temperature levels). As such, water temperature controls everything about a fish's life, such as physiological function (oxygen/carbon dioxide exchange, blood chemistry/pH, organ function, heart rate, growth, endocrine functions, egg and sperm viability), basic survival, food consumption, rearing location preference, ability to successfully spawn, spawning location preference, growth rates, stress factors, immune function, disease resistance, predator avoidance, etc. Water temperature is as important to fish as air quality is to humans, and, how the population responds over time is of great concern.

V. Abundance of a given lifestage is not evenly distributed through time or space and CDFG's analysis does not account for the proportion of the population that may be exposed to the conditions that they have defined as impaired. For example, if 5 out of 20 weeks are impaired, CDFG's approach would calculate that the lifestage is 25% impaired. However, if only 5% of the population was present during that 5 week period, CDFG's approach would have overestimated the impairment fivefold.

If five out of 20 weeks are impaired due to high water temperature then the overall quality of habitat for a given life history stage normally occurring then is impaired by 25%. The issue of presence and abundance (e.g., relative intensity of habitat use over time), and factors leading up to (or determining) presence and abundance, are separate questions and issues.

Presence of adult salmon in the east-side tributaries is influenced by water temperature, and other water quality parameters such as dissolved oxygen in the Stockton Deep Water Ship Channel (Hallock 1970). Water temperature in the Stockton Deep Water Ship Channel is dependent upon San Joaquin River inflows and river water temperature levels. San Joaquin River inflows are dependent upon several factors including mainstem river flow levels, east-side tributary flow levels, east-side tributary reservoir storage and release water temperature levels, and ambient air temperature level.

In short, instream flow water and temperature levels in the San Joaquin River is a controlling factor when salmon migrate through the South Delta and into the east-side tributaries. The San Joaquin River Group Authority comment on our previous page "IV" points out there are many factors important to individual fish survival in play in the smolt life stage. Additionally, temperature is a controlling factor determining when and where salmon will spawn. Appendix J shows an example of how salmon redd counts increase sharply when water temperature decrease into a suitable range (e.g. ≤13°C). Thermal units determine embryo development rates and the time period for egg hatching and thence fry emergence. Further, water temperature influences growth rates and growth rates influence both size, timing of out-migration, and survival. In summary water temperature is a very important factor controlling habitat quality and both fish presence and abundance population survival.

Evidence submitted to the Regional Water Quality Control Board (provided by the Department, Mr. John Bartholow, and Dr. Alice A. Rich) strongly suggests that water temperature, in combination with instream flow level, is controlling timing of habitat quality and habitat use, and that timing of habitat use (e.g. spawning habitat for example) influences egg emergence, juvenile abundance, and out-migration timing. To say that only 5% of a population is affected mis-characterizes the conditions that led up to the timing of the species being present (i.e later arrival for adult migrants due to elevated temperatures and low dissolved oxygen at the Stockton Deep Water Ship Channel), in specific quantity, and a specific location. Implying that cutting off habitat and a relatively small number of individuals using that habitat is acceptable is not consistent with principles of population ecology and genetic integrity. To say that a certain number of individuals are expendable is not a prudent management action given that fall-run Chinook salmon in the San Joaquin River tributaries are at a high risk of extinction (e.g. Tuolumne River...Mesick 2008) and steelhead populations are low in abundance.

VI. The EPA criteria are based on constant laboratory conditions which are not directly comparable to diurnally fluctuating field conditions. Fish in the wild are acclimated to the mean of the average and maximum temperatures, and are not constantly exposed to the 7DADM temperatures. As such, the criteria assume a constant exposure to a given temperature rather than potentially brief exposure under diurnally fluctuating conditions.

"The EPA criteria are based on constant laboratory conditions which are not directly comparable to diurnally fluctuating field conditions." This statement is not factually correct and infers that the EPA criteria were based solely upon laboratory studies. Our understanding is that EPA criteria were based upon an exhaustive review of laboratory and field studies which individually, and cumulatively, shed light on the relationship between fish response (e.g. growth, mortality, endocrine response etc) and a variety of water temperature metrics (e.g. daily average, daily max etc).

Regarding use of the 7DADM, EPA, in their Region 10 Guidance For Pacific Northwest State and Tribal Temperature Water Quality Standards (2003), said this:

> "This metric is recommended because it describes the maximum temperatures in a stream, but is not overly influenced by the maximum temperature of a single day. Thus, it reflects an average of maximum temperatures that fish are exposed to over a weeklong period. Since this metric is oriented to daily maximum temperatures, it can be used to protect against acute effects, such as lethality and migration blockage conditions. This metric can also be used to protect against sub-lethal or chronic effects (e.g., temperature effects on growth, disease, smoltification, and competition)..."

EPA (2003) also stated:

> "It is important to note that there are also studies that analyzed sub-lethal effects based on maximum or 7DADM temperature values which need not be translated for purposes of determining protective 7DADM temperatures. For example, there are <u>field studies</u> (emphasis added) that assess probability of occurrence or density of a specific species based on maximum temperatures [Issue Paper 1, Haas (2001), Welsh et al. (2001)]. These <u>field studies</u> (emphasis added) represent an independent line of evidence for defining upper optimal temperature thresholds, which complements laboratory studies."

As such, this criteria (e.g. 7DADM) is a chronic threshold to protect a population of anadromous fish across multiple generations. In addition, this is an average, meaning a range of values, not constant values, were used to calculate a criteria value. Elevated daily temperatures across 7 days indicates the fish are not being briefly exposed across time. The daily water temperature range fluctuation is narrow in the San Joaquin River and tributaries, thus the fish are not briefly exposed to elevated temperatures. Also, there is uncertainty as to whether fish have the luxury of a brief exposure to optimal cool temperatures during a 24-hour period in the San Joaquin Valley Basin river systems.

VII. Adverse biological impacts associated with attempting to meet temperature criteria through increased flow have not been addressed. For example, increasing flows down the Stan during fall to meet temp criteria will result in negative consequences for spawning Chinook. Flood control releases on the Stanislaus during fall 2006 delayed spawning and very little spawning activity occurs during annual attraction pulses. Other biological issues may include de-watering and stranding and the relationships of these factors to instream flow will differ by stream.

Not meeting cool temperature criteria is a biological impact. It serves no purpose to improve spawning habitat only to have adult salmon not be able to utilize it or have non-viable eggs spawned due to temperature associated stress. It is difficult to observe or determine whether or not fish have spawned or are spawning in flows above 500 cfs in the Stanislaus River. So it is unknown if spawning is truly impaired at higher flow levels. That said, the pattern across the historical years of record for the altered water regime is to have excessively high water temperatures during some, if not most, of the spawning period. The result is an unstable and declining fall-run Chinook salmon population that has declined catastrophically in one or more San Joaquin River tributary (i.e. Tuolumne River). The Department believes long term production benefits associated with reduced water temperatures for outweigh the possible impacts of dewatering (e.g. reference to fish that may have spawned in stream margin areas at high flows then are dewatered when flows are ramped down) or stranding.

VIII. The approach used by CDFG does not consider whether fish utilize potential areas of thermal refugia such as pools and areas of groundwater upwelling. During June 1989 a groundwater source in the Tuolumne River was identified where temperatures were about 5°F (~3°C) cooler than the surrounding water (EA Engineering 1992).

Water temperature monitoring demonstrates no significant area of cool water refugia of significance of the overall population. The Department acknowledges that limited isolated areas of temperature refugia may still exist that could provide improved habitat conditions for a relatively few resident fish or short duration refuge for migrating fish. However, it is important to comprehend that: 1) these refuges do not substantively reduce water temperature for large habitat areas, either individually or collectively, for if they did we would see abrupt sustained cooling at one or more sites and neither the empirical data nor the HEC5Q model results demonstrate this; 2) population level impacts occur when temperature impairment over a wide portion of a particular life history stage is present. The Department's temperature assessment indicates that water temperature impairment is occurring temporally (time/duration) and spatially (reach length) for several life history stages (e.g. adult migration, spawning, smolt migration, and summer rearing etc.) and populations continue to decline.

<u>Page 34.</u> This year both salmon commercial and sportfishing has been terminated at the expense of millions of dollars loss to the industries, including commercial and retail markets and restaurants. The forecast for next year is similar for San Joaquin Basin stocks.

The Department and other stakeholders (including the San Joaquin River Group Authority members) have recent spent millions of dollars creating spawning and rearing habitat for fish. However, this effort is fruitless if the fish do not have high quality water during the correct biological timing to be useful and successful.

We concur that exotic predatory fish can impact native species, but species such as striped bass have special interest groups in California who strongly supported this fishery. It is important to note that river temperature regimes favoring anadromous salmonids generally disfavor many predatory fish species population abundance levels.

Below is the entire paragraph from Williams (2006).

> "The predicted increase in temperature begs the question whether Central Valley salmon are a lost cause, so that efforts to protect salmon are a waste of resources that should be applied elsewhere. **The answer seems to be, probably not yet,** because the modeling also shows that the extent of future warming depends largely on future emissions (Hayhoe et al. 2004). Although it may be too late for spring-run in Butte Creek, or perhaps for any Central Valley salmon, if the more extreme predictions considered most likely by Dettinger (2005) turn out to be correct, there is still time for effective actions to reduce future greenhouse gas emissions. Effective actions to reduce the extent of warming are desperately needed for many reasons besides salmon conservation, and may yet be taken."

Note that he added a clarification statement, "The answer seems to be, probably not yet,......"

We concur that climate change and global warming is a new and upcoming challenge to the Department, the State of California, and the nation. However, on an evolutionary scale, native species have under gone the earth's warming and cooling periods across thousands of generations and still exist today. As such, we do not concur with the opinion that the effort to protect the last remaining salmon and steelhead in the San Joaquin River Basin is a "lost cause". As the trustee agency, we are required by California law to protect these natural resources.

<u>Page 35 to 40.</u> We do not concur with the suggested SJRGA approach to use a model to re-write history. Models are designed to use existing data to develop a model, calibrate the model and to predict future management outcomes based on developed/known historical empirical data. The SJRGA's consultant modeled the Stanislaus River temperature backwards to re-write history using today's environmental and physical conditions. Keep in mind that these rivers were significantly altered (dams, mining, diversions, channelization, levees, etc.) by the 1960's and 1970's, thus does not represent the natural environmental conditions that native fish co-evolved. The SJRGA model output and presentation also failed to recognize that fish once could migrate up to higher elevation cooler waters, but today are blocked by dams.

The SJRGA indicated that salmon were abundant in 1970. The use of the term "abundant" is relative. More fish were in the Basin in the 1960's, even more in the 1950's, more in the 1940's and so on and so on. Chinook salmon and steelhead have continued to decline since European settlers entered California. Today's water management in the San Joaquin River Basin clearly is not improving native fish populations across time.

Summary
Historically, over fifty percent of California's Central Valley was some sort of wetland. Riparian zone stretched wide distances on each side of river and stream banks (*Warner, Richard E., and Kathleen M. Hendrix, 1984. California Riparian Systems: Ecology, Conservation, and Productive Management. Berkeley:University of California Press*). California has lost over 95% of its the historical wetlands (*USFWS 1978. Concept plan for waterfowl wintering habitat preservation. Central Valley California. Portland, Oregon*) and today, riparian zones in most places are down to narrow strips (i.e. one row of trees) or none at all. Water temperatures are one of many variables that anadromous fish need to successfully reproduce and survive. Neither we nor the CVRWQCB can not address all the variables at once, but at least concentrate our efforts to what we believe are the most significant to address. The other variables will be addressed in the future. Clearly the fall-run Chinook salmon populations have crashed and steelhead are low in abundance yet, both still persist. We believe that lack of reproduction success and recruitment in our altered river system is one of the most significant factors that we can address. Under current water management, this is a dwindling natural resource. If management regulatory efforts are not immediate to protect these fish, another alternative is for these fish to become listed as endangered under state and federal law, which is even more restrictive on the beneficial uses or water.

A final note, some believe that is it acceptable to cut-off the front (i.e. adult migration/ spawning) or back-end (e.g. smolt out-migration) of a particular life history stage production simply because it is operationally speaking (i.e. reservoir operations) expedient to do so in the name of water conservation or other water use. Truncating the fish production process does not make sense biologically nor genetically, as it exacerbates this stocks ability to survive and adapt over time. For example, if it is desired to move the smolt out-migration season up (e.g. have majority of smolts leave earlier than presently occurs) then spawning must start earlier. However, spawning cannot start earlier if excessively warm water temperatures are present during the early part of the adult migration and spawning season. Genetically speaking, it is not prudent to remove a substantial part of the population's gene pool (i.e., select for) simply because it is operationally expedient (i.e. desirable) to do so. Genetic health, and the ability of a population to endure, is compromised when the gene pool is bottlenecked. Cutting off the "tails" of the fall adult migration/spawning or spring rearing production seasons needs serious examination to ensure that population abundance and genetic health impacts do not occur at levels greater than exists today. Again in addition to restrictions, the geographic range with dams, the historical pattern is to cut-off the front end of the adult migration/spawning run timing and the tail-end of the juvenile out-migration seasons timing due to excessively warm water temperatures. The net result is an unstable and declining fall-run Chinook salmon population that has declined to the point of being at a high rate of extinction in at least one San Joaquin River tributary (i.e. Tuolumne River).

Appendix A.

Dr. Peter Moyle's Commentary on Central Valley Chinook Salmon Decline.

http://www.indybay.org/newsitems/2008/04/06/18490965.php

Central Valley | Environment & Forest Defense

Peter Moyle's Commentary on Central Valley Chinook Salmon Decline
by Dan Bacher
Sunday Apr 6th, 2008 9:02 PM

For the first time in history, recreational fishing boats in Santa Cruz, Moss Landing, Monterey, Morro Bay and other ports along the northern and central California Coast didn't go out fishing for chinook salmon on the traditional opening day of the season. The boats stayed in port on Saturday, April 5, due to an unprecedented emergency closure imposed by the Pacific Fishery Management Council (PFMC).

The federal PFMC and the National Marine Fisheries Service (NMFS) in March took action to close the already open ocean sport fishery between Horse Mountain and Point Arena on April 1, 2008. In addition, they took emergency action to close the April 5 sportfishing openers in San Francisco and Monterey port areas (south of Point Arena to the U.S.-Mexico Border).

"These actions are being taken to protect Sacramento River fall Chinook salmon which returned to the Central Valley in 2007 at record low numbers," according to a statement from the California Department of Fish and Game. "Even if all ocean sport and commercial fisheries are closed throughout California, salmon returns are not projected to meet the escapement goals required by the PFMC Salmon Fishery Management Plan."

The PFMC has produced three ocean salmon fishing season "options" (effective May 1, 2008 through April 30, 2009) for public comment.

Option 1 provides very limited commercial and sport fishing after May 18.
Option 2 provides no commercial or sport fishing after March 31 but allows a non-retention research project to collect tissue samples for genetic stock identification analyses.
Option 3 provides no fishing between Cape Falcon, Oregon and the U.S.-Mexico border.

The PFMC will meet April 7-11 in Seattle to adopt a final regulatory packet from the three "options" listed above. More information regarding the PFMC meetings and options can be found on the PFMC Web site at http://www.pcouncil.org/.

The impact of these closures will be devastating to the lives of fishermen, fisherwomen, and the thousands of people employed by businesses that depend upon healthy runs of salmon.

In light of the salmon disaster, the following is an excellent commentary on the Central Valley Chinook Decline by Peter B. Moyle, Professor of Fish Biology, University of California Davis, on Google News.

Moyle gives a brief history of the many factors that led to the historic decline that culminated in the unprecedented salmon collapse. He explains the complex interaction between freshwater conditions and ocean conditions - and how "blaming 'ocean conditions' for salmon declines is a lot like blaming the iceberg for sinking the Titanic, while ignoring the many human errors that put the ship on course for the fatal collision."

"'Ocean conditions' may be the potential icebergs for salmon populations but the ship is being steered by us humans. Salmon populations can be managed to avoid an irreversible crash, but continuing on our present course could result in loss of a valuable and iconic fishery," says Moyle.

He lists short run remedies as well as long term solutions to the salmon dilemma - and closes with an optimistic note that "there is a reasonable chance that Chinook salmon populations will once again return to higher levels, as they have in the past, although not quickly."

Comment by Peter B Moyle, Professor of Fish Biology, University of California Davis

Multiple Causes Of Central Valley Chinook Salmon Decline - Mar 31, 2008

Ever since EuroAmericans arrived in the Central Valley, Chinook salmon populations have been in decline. Historic populations probably averaged 1.5-2.0 million (or more) adult fish per year. The high populations resulted from four distinct runs of Chinook salmon (fall, late-fall, winter, and spring runs) taking advantage of the diverse and productive freshwater habitats created by the cold rivers flowing from the Sierra Nevada. When the juveniles moved seaward, they found abundant food and good growing conditions in the wide valley floodplains and complex San Francisco Estuary, including the Delta. The sleek salmon smolts then reached the ocean, where the southward flowing, cold, California Current and coastal upwelling together created one of the richest marine ecosystems in the world, full of the small shrimp and fish that salmon require to grow rapidly to large size. In the past, salmon populations no doubt varied as droughts reduced stream habitats and as the ocean varied in its productivity, but it is highly unlikely the numbers ever even approached the low numbers we are seeing now.

Unregulated fisheries, hydraulic mining, logging, levees, dams, and other factors caused precipitous population declines in the 19th century, to the point where the salmon canneries were forced to shut down (all were gone by 1919). Minimal regulation of fisheries and the end of hydraulic mining allowed some recovery to occur in the early 20th century but the numbers of harvest salmon steadily declined through the 1930s. There was a brief resurgence in the 1940s but then the effects of the large rim dams on major tributaries began to be severely felt. The dams cut off access to 70% or more of historic spawning areas and basically drove the spring and winter runs to near-extinction. In the late 20th century, thanks to hatcheries, special flow releases from dams, and other improvements, salmon numbers (mainly fall-run Chinook) averaged nearly 500,000 fish per year, with wide fluctuations from year to year, but only about 10-25% of historic abundance. In 2006, numbers of spawners dropped to about 200,000, despite closure of the fishery. In 2007, the number of spawners fell further to about 90,000 fish, among the lowest numbers experienced in the past 60 years, with expectations of even lower numbers in fall 2008 (probably <64,000 fish). The evidence suggests that these runs are largely supported by hatchery production, so numbers of fish from natural spawning are much lower.

So, what caused this apparently precipitous decline in salmon? Unfortunately, the causes are historic, multiple and interacting. The first thing to recognize is that Chinook salmon are beautifully adapted to living in a region where conditions in both fresh water and salt water can alternate between being highly favorable for growth and survival and being comparatively unfavorable. Usually, conditions in both environments are not overwhelmingly bad together, so when survival of juveniles in fresh water is low, those that make it to salt water do exceptionally well. And vice versa. This ability of the two environments to compensate for one another's failings, combined with the ability of adult salmon to swim long distances to find suitable ocean habitat, historically meant salmon populations fluctuated around some high number. Unfortunately, when conditions are bad in both environments, populations crash, especially when the heavy hand of humans is involved.

The recent crash has been blamed largely on "ocean conditions." Generally what this means is that the upwelling of cold, nutrient-rich water has slowed or ceased, so less food is available, causing the salmon to starve or move away. Upwelling is the result of strong steady alongshore winds which cause surface waters to move off shore, allowing cold, nutrient-rich, deep waters to rise to the surface. The winds rise and fall in response to movements of the Jet Stream and other factors, with both seasonal and longer-term variation. El Nino events can affect local productivity as well, as can other 'anomalies' in weather patterns. And Chinook salmon populations fluctuate accordingly.

The 2006 and 2007 year classes of returning salmon mostly entered the ocean in the spring of 2004 and 2005, respectively (most spawn at age 3). Although upwelling should have been steady in this period, conditions unexpectedly changed and ocean upwelling declined in the spring months, so there were fewer shrimp and small fish for salmon to feed on. According to an analysis by an interdisciplinary group of scientists, conditions were particularly bad for a few weeks in spring of 2005 in the ocean off Central California, resulting in abnormally warm water and low concentrations of zooplankton, which form the basis for the food webs which include salmon. All this could have caused wide scale starvation of the salmon. Note the emphasis on could. While the negative impact of ocean anomalies is likely, monitoring programs in ocean are too limited to make direct links between salmon and local ocean conditions.

"Ocean conditions" can also refer to other factors which can be directly affected by human actions, especially fisheries. For example, fisheries for rockfish and anchovies can directly or indirectly affect salmon food supplies (salmon eat small fish). Likewise, fisheries for sharks and large predators may have allowed Humboldt squid (which grow to 1-2m long) to become extremely abundant and move north into cool water, where they could conceivably prey on salmon. These kinds of effects, however, are largely unstudied.

Meanwhile, what has been going on in the Sacramento and San Joaquin rivers? On the plus side, dozens of stream and flow improvement projects have increased habitat for spawning and rearing salmon. Removal of small dams on Butte Creek and Clear Creek, for example, has increased upstream run sizes dramatically. Salmon hatcheries also continue to produce millions of fry and smolts to go to the ocean. On the contrary side:

* The giant pumps in the South Delta have diverted increasingly large amounts of water in the past decades, altering hydraulic and temperature patterns in the Delta as well as capturing fish directly.
* The Delta continues to be an unfavorable habitat for salmon, especially on the San Joaquin side where the inflowing river water is warm and polluted with salt and toxic materials. Most of the rest of the Delta lacks the edge habitat juvenile salmon need for refuge and foraging.
* Hatchery fry and smolts are released in large numbers but their survivorship is poor, compared to wild fish, although they contribute significantly to the fishery. Nevertheless, they may be competitors with better-adapted wild fish under conditions of low supply in the ocean. Most of the hatchery fish are planted below the Delta, to avoid the heavy mortality there.
* Numbers of salmon produced by tributaries to the San Joaquin River (Merced, Tuolumne, Stanislaus) continue to be exceptionally low, in the hundreds, and the promised restoration of the San Joaquin River appears to be stalled for lack of federal funds.

Thus reduced survival of wild fish in fresh water, especially in the Delta, combined with the naturally low survival rates of hatchery fish; most likely contribute to the plummeting numbers of adult spawners. This is especially likely to happen if young salmon also hit adverse conditions in the ocean, especially as they enter the Gulf of the Farrallons. The growing salmon can also hit other periods when food is scarce in the ocean, along with abundant predators and stressful temperatures, at any time in the ocean phase of their life cycle.

The overall message here is that indeed "ocean conditions" have had a lot to do with the recent crash of salmon populations in the Central Valley. However, they are superimposed on a population that has been declining in the long run (with some apparent stabilization in recent decades). The salmon still face severe problems before they reach the ocean, especially in the Delta. In the short run, there are only a few 'levers' we can pull to improve things for Central Valley salmon which include shutting down the commercial and recreational fisheries, reducing the impact of the big pumps in the South Delta, and perhaps changing the operation of dams (increasing outflows at critical times), regulating hatchery out put, and reducing other ocean fisheries. In the longer run (10-20 years) we need to be engaged in improving the Delta and San Francisco Estuary as a habitat for salmon, reducing inputs to the estuary of toxic materials, continuing with improvements of upstream habitats, managing floodplain areas such as the Yolo Bypass for salmon, restoring the San Joaquin River, and generally addressing the multiplicity of factors that affect salmon populations. There is also a huge need to improve monitoring of salmon in the ocean as well as the coastal ocean ecosystem off California. Right now, our understanding of how ocean conditions affect salmon is largely educated guesswork with guesses made long (sometimes years) after an event affecting the fish has happened. An investment in better knowledge should have large pay-offs for better salmon management.

Thus blaming "ocean conditions" for salmon declines is a lot like blaming the iceberg for sinking the Titanic, while ignoring the many human errors that put the ship on course for the fatal collision. Managers have optimistically thought that salmon populations were unsinkable, needing only occasional course corrections such as hatcheries or removal of small dams, to continue to go forward. The listings as endangered species of the winter and spring runs of Central Valley Chinook were warnings of approaching disaster on an even larger scale. "Ocean conditions" may be the potential icebergs for salmon populations but the ship is being steered by us humans. Salmon populations can be managed avoid an irreversible crash, but continuing on our present course could result in loss of a valuable and iconic fishery.

On a final more optimistic note, there is a reasonable chance that Chinook salmon populations will once again return to higher levels, as they have in the past, although not quickly. However, the lower the population goes and the more the environment changes in unfavorable ways, the more difficult recovery becomes.

Recovery is officially defined by the goals set by the Anadromous Fish Restoration Program under the Central Valley Project Improvement Act which has pledged to use "all reasonable efforts to at least double natural production of anadromous fish in California's Central Valley streams on a long-term, sustainable basis". The final doubling goal is 990,000 fish for all four runs combined. We have a long way to go and some major course modifications to make if we are to reach anything close to that goal.

Appendix B.

Carl Mesick Manuscript

The High Risk of Extinction for the Natural Fall-Run Chinook Salmon Population in the Lower Tuolumne River due to Insufficient Instream Flow Releases

Carl Mesick, Ph.D.
Stockton Fishery Resource Office
US Fish and Wildlife Service
30 April 2008

The following preliminary analysis indicates that the Tuolumne River fall-run Chinook salmon *(Oncorhynchus tshawytscha)* population of naturally produced fish is at a high risk of extinction because the instream flow releases are too low. Lindley and others (2007) have characterized the risk of extinction for Chinook salmon populations in the Sacramento-San Joaquin Basin relative to population size, rates of population decline, catastrophes, and hatchery influence. Populations with a high risk of extinction (greater than 20 percent chance of extinction within 20 years) have a total escapement that is less than 250 spawners in three consecutive years (mean of 83 fish per year), a precipitous decline in escapement, a catastrophe defined as an order of magnitude decline within one generation occurring within the last 10 years, and a high hatchery influence. Populations with a low risk of extinction (less than 5 percent chance of extinction in 100 years) have a minimum total escapement of 2,500 spawners in three consecutive years (mean of 833 fish per year), no apparent decline in escapement, no catastrophic declines occurring within the last 10 years, and a low hatchery influence. The Tuolumne River fall-run Chinook salmon population is at a high risk of extinction because the population of naturally produced fish was probably less than 83 for three consecutive years (2005 to 2007), there was a precipitous decline, and the fall 2007 escapement was a catastrophe considering the spring 2005 wet year conditions. Dr. Steve Lindley[1] evaluated the Tuolumne River population estimates in Table 1 and confirmed these conclusions. The following summarizes the risk of extinction based on the four criteria presented by Lindley and others (2007).

Population Size

The effective population size criteria relates to the loss of genetic diversity (Lindley et al. 2007). The effective population consists of individuals that are reproductively successful. In Chinook salmon populations, not all individuals are reproductively successful and the mean ratio of the effective population size to total escapement over a three year period (N_e/N) has been estimated to be 0.20 based on genetic assessments from fish collected in over 100 populations from California to British Columbia (Waples et al. 2004 as cited in Lindley et al. 2007). A few examples of why adult salmon may not reproduce successfully in the Tuolumne River include: (1) fish that return as two-year-old males; (2) redd superimposition that destroys eggs; (3) spawning in habitats with excessive levels of fines; and (4) low survival rates for juveniles that migrate late when high water temperatures in the lower Tuolumne River are unsuitable for survival.

[1] Steven Lindley, Ph.D, National Marine Fisheries Service, Fisheries Ecology Division, 110 Shaffer Road, Santa Cruz, California 95060, phone (831) 420-3921.

Therefore based on population size, the Tuolumne River could be considered to be at high risk if annual escapement (N) drops below a mean of 83 fish for three consecutive years and at low risk if escapement remains above a mean of 833 fish for three consecutive years.

The analyses reported here are based on preliminary estimates of the number of naturally produced and hatchery produced adult fall-run Chinook salmon that have returned to the Tuolumne River between 1981 and 2005 (Table 1). The analyses should be considered as preliminary because the estimates for the returns of untagged adult Feather, Nimbus, and Mokelumne hatchery fish are based on relatively few tagged fish that were collected in the Tuolumne River during escapement surveys (see Methods Summary). These surveys were used to estimate the percentage of the millions of unmarked juvenile hatchery fish released from these hatcheries in the Delta and San Francisco Bay that would have returned to the Tuolumne River (see Methods Summary). The preliminary analyses used simple mean rates of adult returns to the Tuolumne River that were estimated by segregating the juvenile release data into three groups: (1) release location, (2) spring or fall releases, and (3) water year type (Merced and Mokelumne hatcheries only). The mean rates of return do not account for year to year variation due to other factors, such as ocean conditions and fall attraction flows, and the statistical level of confidence has not been evaluated.

Since the license was amended in 1996 to improve minimum instream flows, it is likely that the escapement of naturally produced fish has been less than 83 fish between fall 2005 and 2007 (3 consecutive years, Table 1). Therefore, the Tuolumne River would be considered to be at a high risk of extinction according to the recommended criteria by Lindley and others (2007).

Population Decline

Another serious threat to the viability of natural salmonid populations identified by Lindley and others (2007) is a precipitous decline in escapement, which has occurred on the Tuolumne River. Table 1 indicates that the escapement of natural spawners in the Tuolumne River has declined from about 16,000 adults in fall 2000 to few if any fish between fall 2005 through fall 2007. In addition, the abundance of natural Tuolumne River recruits at a given flow declined by about 50% at a statistically significant level between the 1980 to 1995 pre-Settlement Agreement period and the 1996 to 2004 post-Settlement Agreement period (Figure 2). These results provide additional evidence that the Tuolumne River natural salmon population would be considered to be at a moderate to high risk of extinction according to the recommended criteria by Lindley and others (2007). The studies that have been conducted by the Turlock Irrigation District and the Modesto Irrigation District to date are inadequate to explain the cause of the population's decline (*see* Analyses & Recommended Studies for Fall-run Chinook Salmon and Rainbow Trout in the Tuolumne River, e-Library no. 20070314-0089).

Catastrophe

Catastrophes are defined by Lindley and others (2007) as instantaneous declines in population size due to events that occur randomly in time that reflect a sudden shift from a low risk state to a higher one. The extremely low total escapement of 115 fish in Fall 2007 could be considered a catastrophe. Since the 1940s, fall-run Chinook salmon escapement to the Tuolumne River had been high two years following prolonged winter and spring flows during wet years. For example, during 1996 the mean flow near La Grange Dam was 3,652 cfs between February 1 and June 15 and natural fish escapement in fall 1998 was about 6,940 adult salmon (Table 1). In contrast, during 2005 the mean flow near La Grange Dam was 3,881 cfs between February 1 and June 15, but few if any naturally produced fish returned in fall 2007 (Table 1). Recent findings by the National Marine Fisheries Service (Peterson et al. 2006) indicate that warmer waters in the Pacific Ocean during 2005 caused a decline in marine food production, thus contributing to the marked decline in returning spring Chinook and coho salmon populations along the entire West Coast in 2007. The catastrophically low escapement in fall 2007 is another sign that the Tuolumne River naturally produced Chinook salmon population is at high risk of extinction.

Hatchery Influence

There are no data to directly assess the genetic impacts of adult hatchery fish on the naturally produced Chinook salmon population in the Tuolumne River. If there are impacts from the Feather, Nimbus, and Mokelumne hatchery releases, (an average total of about 570 adults in the Tuolumne River escapement from 1996 to 2005), then the minimum escapement needed to maintain a low risk of extinction would be substantially greater than 1,724 fish.

Minimum Flow Releases

The number of naturally produced adult salmon that return to the Tuolumne River is primarily a response of the juvenile salmon to the flows released at La Grange Dam during the winter and spring (Figure 1; Analyses & Recommended Studies for Fall-run Chinook Salmon and Rainbow Trout in the Tuolumne River, e-Library no. 20070314-0089). The assessment of the relationship between flows and adult salmon production utilizes estimates of adult recruitment, which are adult salmon that all belong to the same cohort and were either harvested in the ocean or returned to spawn in the escapement. Assuming that ocean harvest rates continue to be about 40 percent (mean 2000 to 2006), a recruitment of 1,388 fish would result in an escapement of 833 fish. The polynomial relationship between the average flows from February 1 through June 15 and Tuolumne River adult recruitment (Figure 1) suggests that when the average winter and spring flows are less than 1,330 cfs, the average adult recruitment of naturally produced salmon is less than 1,388 fish.

There is uncertainty regarding the precise duration and timing of the spring pulse flows needed to produce 1,388 adult Tuolumne River recruits. The correlations between flow releases and salmon recruitment are probably highest for the February 1 through June 15 period because extended floodplain inundation that occurs during wet years produces good conditions for both rearing and migrating juveniles. The exponential increase in recruitment as flows increase above 2,000 cfs (Figure 1) probably reflects the importance of the extended floodplain inundation. Under typical dry and normal water year conditions, it is likely that high flows are primarily protecting outmigrating subyearling smolts in April and May. Therefore, it is likely that the 1,330 cfs pulse flows would have to occur when most of the smolt-sized fish are migrating and conditions are suitable for their survival in the Delta. Studies will be needed to determine the precise timing and duration of these pulse flows (*see* Analyses & Recommended Studies for Fall-run Chinook Salmon and Rainbow Trout in the Tuolumne River, e-Library no. 20070314-0089). In addition to spring pulse flows, it would be necessary to provide fall pulse flows to minimize the straying of adults to the Sacramento Basin and suitable year-round base flows for spawning, egg incubation, and rearing. A minimum flow schedule that should be able to sustain both naturally producing Chinook salmon and *O. mykiss* (steelhead and rainbow trout) populations includes the following three elements:

- Pulse flows of 1,330 cfs for 45 days during April and May to provide suitable conditions for migrating juvenile salmon and Central Valley steelhead.
- Fall pulse flows of 1,500 cfs for 10 days during mid-October to attract adult Chinook salmon to the Tuolumne River and minimize straying (Mesick 2001).
- Year round base flows of 235 cfs to provide suitable water temperatures throughout the summer in 12.4 miles of habitat for *O. mykiss* (unpublished results of real-time temperature management by Turlock Irrigation District and Modesto Irrigation District in 2002 and 2003) and suitable spawning and rearing conditions for fall-run Chinook salmon.

The total volume of water required for this flow schedule is 292,889 acre-feet (AF). In comparison, the volume of flow releases required in the Tuolumne River in the 1996 FERC order range from 94,000 AF in Critical and Below Normal Water Year Types to 165,002 AF in Median Below Normal water year types (Turlock Irrigation District and Modesto Irrigation District 2005). These relatively dry water year types cumulatively occur 50.7% of the time (Turlock Irrigation District and Modesto Irrigation District 2005). During the wetter water year types (49.3% of the time), the required flow release is 300,923 AF (Turlock Irrigation District and Modesto Irrigation District 2005).

Methods Summary

The analyses described here are based on trends in adult recruits, which are adult salmon that all belong to the same cohort and were either harvested in the ocean or returned to spawn in the escapement. Approximately 40% of the adult recruits have been harvested in the ocean between 2000 and 2006.

The number of recruits is estimated by first segregating the California Department of Fish and Game (CDFG) escapement estimates (GrandTab Excel file, February 20, 2008) into cohorts using an age analysis of fall-run Chinook salmon scales collected from the Tuolumne River between 1981 and 2002 that was conducted by CDFG. The abundance of recruits is then expanded by an index of the percentage of fish harvested in the ocean

(Central Valley Index, Pacific Fisheries Management Council 2006). These methods are described in greater detail in Mesick and Marston (2007) and Mesick, Marston, and Heyne (2007).

The escapement estimates for the lower Tuolumne River in the CDFG database are a combination of naturally produced and hatchery fish. To estimate the number of hatchery reared fish, it was necessary to expand the number coded-wire-tagged (CWT) hatchery adults that returned to the Tuolumne River (Table 2) as well as estimate the number of untagged hatchery fish that were reared in the Merced, Mokelumne, Nimbus (American River), and Feather river hatcheries and returned to the Tuolumne River as adults (Table 3). Expanding the number of CWT fish is a relatively simple computation based on the number of hatchery fish, which are identified with an adipose fin clip, that are observed during the escapement survey, the number of salmon examined for tags, and the total number of salmon in the escapement. These data are considered to be relatively accurate for the lower Tuolumne River. Expanding the number of unmarked fish assumes that the unmarked fish return to the Tuolumne River at the same rate that the marked fish return to the Tuolumne River.

Based on the CWT recoveries in the Tuolumne River, most of the unmarked fish originate from planting juvenile fish in the San Francisco Bay from the Mokelumne, Nimbus, and Feather River hatcheries, in the Delta from the Mokelumne River Hatchery, and in the Merced River from the Merced River Hatchery.

The number of unmarked fish released from each hatchery was obtained from the CDFG annual reports for the Feather, Nimbus, Mokelumne, and Merced hatcheries. Some of the Merced hatchery release data was obtained from planting release records. Expansions of the unmarked hatchery fish were based on the CWT return rates segregated by release location (e.g., river, Delta, or Bay) and whether releases were spring sub-yearling fish or fall yearlings. The expansions for Merced River, Mokelumne River, and Delta releases were also segregated into wet (San Joaquin Index > 3.1 million acre-feet) and dry year conditions (San Joaquin Index ≤ 3.1 million acre-feet); water year type did not substantially affect the return rates for juveniles planted in the Bay. The analyses were conducted using Microsoft Excel spreadsheets and data were sorted into the various release categories (e.g., River, Delta, and Bay) using pivot tables. The escapement of naturally produced salmon was computed by subtracting the estimated number of marked and unmarked hatchery fish that returned to the Tuolumne River from the CDFG escapement estimate.

Preliminary Results

Figure 1. The number of natural adult recruits relative to the average flow release from La Grange Dam from February 1 through June 15 when the cohorts migrated as juveniles toward the ocean from 1996 to 2004. The polynomial equation and the R^2 value computed by Excel are presented for the relationship.

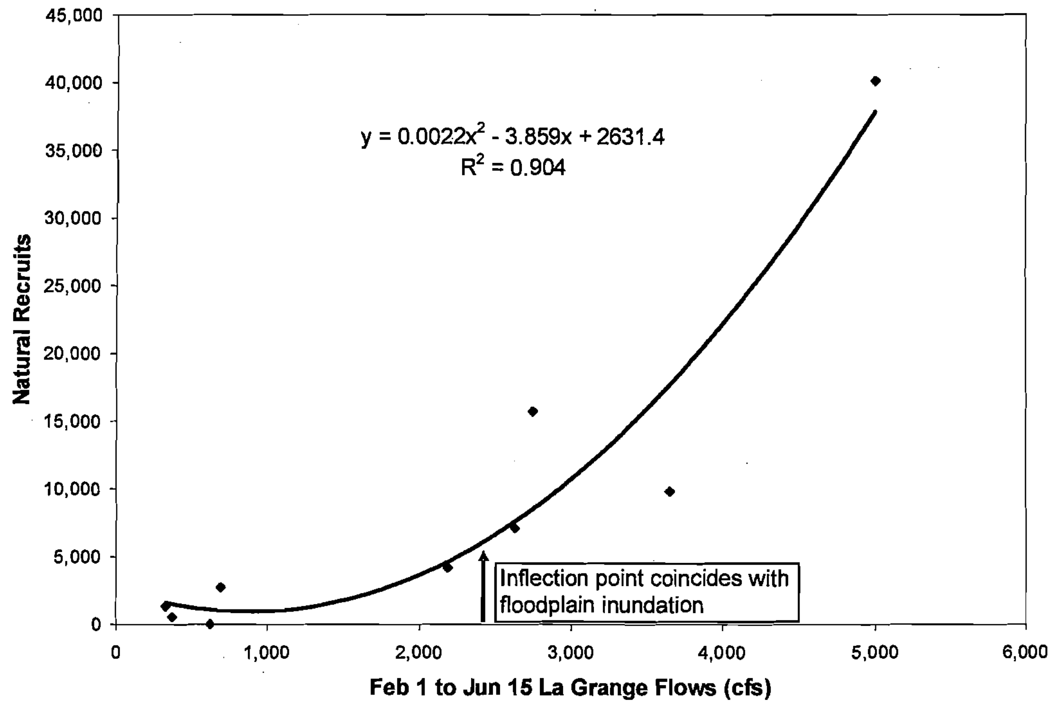

Figure 2. Tuolumne River natural fall-run Chinook salmon recruitment plotted with mean flow in the Tuolumne River at La Grange during February 1 through June 15 during two periods: 1980 to 1990 and from 1997 to 2003. Estimates were excluded when spawner abundance was less than 650 Age 3 equivalent fish to minimize the effect of spawner abundance on the relationship between flow and recruitment. An *F* test comparing the two data sets indicate that the elevations of the two regressions are significantly different ($P = 0.011$). The variance terms of the two data sets were not statistically different ($P = 0.301$), which is a condition required to compare the slopes and elevations of the two regressions, and the slopes were not significantly different ($P = 0.056$) (Snedecor and Cochran 1989, pages 390-393).

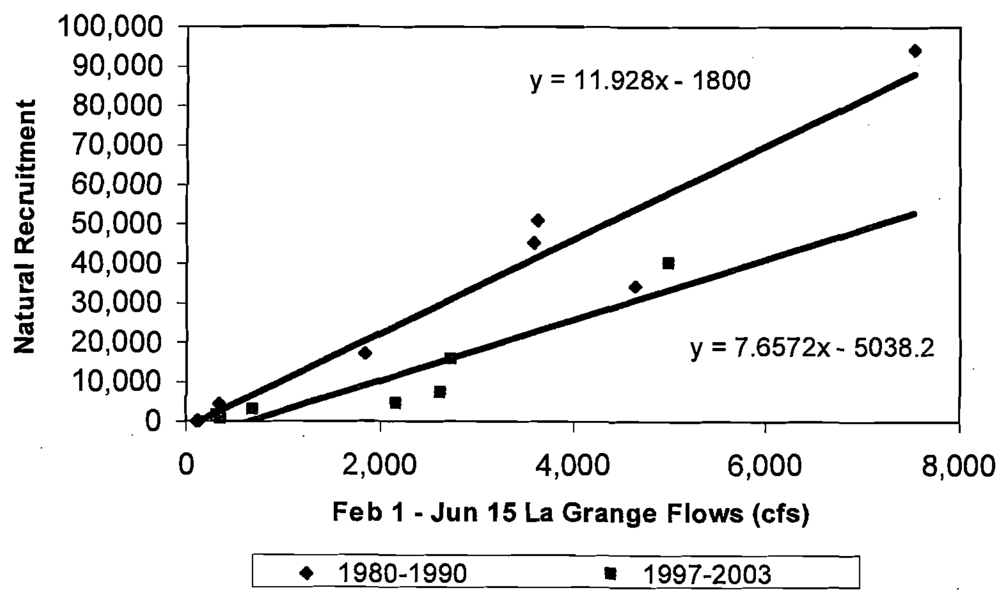

Table 1. The Department of Fish and Game estimated escapement of fall-run Chinook Salmon in the Tuolumne River (GrandTab), the estimated total number of marked (coded-wire tag and adipose clipped) adults that returned to the Tuolumne River, the estimated number of unmarked hatchery adults from the Mokelumne, Nimbus, Feather, and Merced river hatcheries that returned to the Tuolumne River, the estimated escapement of naturally produced adults, the escapement of hatchery produced adults, and the percent hatchery fish in the escapement from 1978 to 2007. The estimates of unmarked adults are based on bay releases from the Nimbus and Feather River hatchery, Delta and Bay releases from the Mokelumne Hatchery, and Merced River releases from the Merced River Hatchery. The estimates of natural escapement were truncated at zero. The estimates of natural escapement for 2006 and 2007 assume that the average number of out-of-basin hatchery strays that returned to the Tuolumne River between 1996 and 2005, which is 570 fish, also returned in 2006 and 2007.

			Unmarked Adults						
	Total Escapement	Marked Hatchery Fish	Mokelumne Hatchery	Nimbus Hatchery	Feather River Hatchery	Merced River Hatchery	Estimated Natural Escapement	Estimated Hatchery Escapement	Percent Hatchery
1981	14,253	0	57	1	80	9	14,106	147	1.0%
1982	7,126	30	94	22	83	0	6,897	229	3.2%
1983	14,836	430	82	60	143	0	14,121	715	4.8%
1984	13,689	31	91	69	187	0	13,312	377	2.8%
1985	40,322	208	105	66	195	0	39,747	575	1.4%
1986	7,404	143	75	68	247	1	6,871	533	7.2%
1987	14,751	1,619	74	71	372	43	12,571	2,180	14.8%
1988	5,779	270	104	75	406	105	4,819	960	16.6%
1989	1,275	175	133	71	430	59	407	868	68.1%
1990	96	98	160	68	410	5	0	741	100%
1991	77	20	188	69	332	5	0	613	100%
1992	132	23	173	65	277	4	0	542	100%
1993	471	118	161	59	229	3	0	569	100%
1994	506	107	199	57	432	1	0	797	100%

			Unmarked Adults						
	Total Escapement	Marked Hatchery Fish	Mokelumne Hatchery	Nimbus Hatchery	Feather River Hatchery	Merced River Hatchery	Estimated Natural Escapement	Estimated Hatchery Escapement	Percent Hatchery
1995	827	142	185	53	622	0	0	1,002	100%
1996	4,362	881	104	61	601	18	2,696	1,666	38.2%
1997	7,146	1,321	52	68	496	45	5,165	1,981	27.7%
1998	8,910	1,405	85	65	392	23	6,940	1,970	22.1%
1999	8,232	1,043	112	63	333	31	6,650	1,582	19.2%
2000	17,873	1,291	107	66	270	81	16,059	1,814	10.1%
2001	8,782	1,559	130	68	277	62	6,686	2,096	23.9%
2002	7,173	2,650	159	52	278	40	3,994	3,179	44.3%
2003	2,163	490	185	31	231	30	1,197	966	44.7%
2004	1,984	473	192	49	243	23	1,004	980	49.4%
2005	500	142	204	53	295	21	0	716	100%
2006	500	?	?	?	?	?	0	?	100%
2007	115	?	?	?	?	?	0	?	100%

Table 2. The number of coded-wire-tagged hatchery fish produced in the Feather River, Nimbus (American River), Mokelumne River, and Merced River hatcheries that returned to the Tuolumne River as adults from 1980 to 2005. The estimated number of returns to the Tuolumne River in Table 2 are included in the column "Marked Hatchery Fish" in Table 1.

Tagged Feather River Releases in San Francisco Bay					
Release Date	Cwt Number	Number Of Tagged Fish Releases	Number Of Untagged Fish Released	Release Location	Estimated Number Of Adult Returns To The Tuolumne River
06/05/1978	066203	164,766	18,183	Port Chicago	0
08/22/1978	065813	97,000	5,820	Port Chicago	3.02
06/10/1980	066209	88,700	4,375	Port Chicago	0
06/13/1980	066212	79,443	2,457	Port Chicago	0
08/14/1980	065817	77,700	15,538	Benicia	51.30
06/08/1981	066215	78,339	5,536	Port Chicago	91.55
06/09/1981	065821	41,917	4,354	Tiburon Net Pens	0
08/10/1985	065860	23,307	2,335	Emeryville Minor Pt	0
06/29/1988	063104	54,151	657	Port Chicago	0
05/04/1994	062517	102,991	1,467	Benicia	2.02
05/04/1994	062517	102,991	1,467	Benicia	3.73
05/31/1994	062518	101,125	5,455	Benicia	0
05/31/1994	063146	51,804	1,608	Benicia	0
07/18/1994	063805	98,795	4,010	Benicia	4.27
07/18/1994	063806	99,394	3,286	Benicia	3.80
06/30/1995	062531	55,498	845	Crockett	0
06/14/1996	062935	56,900	1,669	Monterey	0
06/16/1996	062933	139,443	13,559	Rodeo Minor Port	0
06/26/1996	062937	150,089	4,802	Rodeo Minor Port	0
06/26/1996	062938	149,440	6,232	Rodeo Minor Port	0
04/24/1997	062542	52,597	909	Feather River	0
05/05/1997	0601060215	24,766	3,764	Port Chicago	0
06/07/1999	062631	50,877	1,038	Wickland Oil	0
06/07/1999	062633	51,964	1,060	Wickland Oil	0
06/07/1999	062636	50,932	1,039	Wickland Oil	0
06/07/1999	062637	49,140	1,003	Wickland Oil	0
06/11/1999	062638	50,827	1,037	Wickland Oil	0
06/20/2000	062658	294,362	7,238	Wickland Oil	0
03/27/2001	062674	46,052	2,732	Rodeo Minor Port	0
03/27/2001	062676	44,021	3,010	Wickland Oil	0
03/27/2001	062678	46,052	2,732	Rodeo Minor Port	0
03/29/2001	062666	42,003	2,872	Wickland Oil	0
03/29/2001	062670	46,642	3,189	Wickland Oil	0

Tagged Feather River Releases in San Francisco Bay					
Release Date	Cwt Number	Number Of Tagged Fish Releases	Number Of Untagged Fish Released	Release Location	Estimated Number Of Adult Returns To The Tuolumne River
03/29/2001	062672	47,369	3,239	Wickland Oil	0
03/29/2001	062673	42,704	2,920	Wickland Oil	3.95
03/29/2001	062673	46,642	3,189	Wickland Oil	4.27
03/29/2001	062674	47,369	3,239	Wickland Oil	0
03/29/2001	062675	42,704	2,920	Wickland Oil	8.54
04/15/2001	062091	202,096	719,407	Wickland Oil	16.86
04/15/2001	062664	202,096	719,407	Wickland Oil	145.77
04/23/2001	062663	142,204	719,713	Wickland Oil	0
04/23/2001	062665	142,204	719,713	Wickland Oil	24.22
04/23/2001	062665	142,204	719,713	Wickland Oil	68.98
05/01/2001	062665	31,384	2,146	Wickland Oil	3.95
05/01/2001	062669	32,082	2,194	Wickland Oil	0
05/01/2001	062670	31,384	2,146	Wickland Oil	0
04/10/2002	060290	263,768	227,882	Wickland Oil	7.07
04/10/2002	060401	263,768	227,882	Wickland Oil	0
04/10/2002	060402	264,738	228,012	Wickland Oil	6.88
04/12/2002	062722	105,753	3,896	Wickland Oil	3.83
04/12/2002	062737	107,348	3,853	Wickland Oil	0
06/09/2003	062773	55,625	1,426	Crockett	0
06/09/2003	062774	53,377	1,369	Crockett	0

Tagged Nimbus Hatchery Releases in San Francisco Bay					
Release Date	Cwt Number	Number Of Tagged Fish Releases	Number Of Untagged Fish Released	Release Location	Estimated Number Of Adult Returns To The Tuolumne River
07/15/1986	065405	48,920	5,800	Berkeley Marina	0
07/16/1986	065406	53,072	70,528	Benicia	4.75
07/09/1987	065407	51,891	524	Berkeley Marina	0
06/20/1988	065411	36,325	220,389	Benicia	0
06/13/1989	065413	41,125	198,867	Benicia	0
06/14/1989	065414	49,848	220,365	Benicia	0
06/16/1989	065415	48,207	241,210	Benicia	26.20
06/21/1989	065412	49,400	283,181	Benicia	0
05/23/2001	065455	98,171	1,227,785	Wickland Oil	51.24
05/23/2001	065456	99,528	285,184	Wickland Oil	0
05/23/2001	065457	99,102	285,992	Wickland Oil	0
05/23/2001	065458	99,297	322,984	Wickland Oil	0
05/23/2001	065459	99,439	322,984	Wickland Oil	16.98

Tagged Nimbus Hatchery Releases in San Francisco Bay					
Release Date	Cwt Number	Number Of Tagged Fish Releases	Number Of Untagged Fish Released	Release Location	Estimated Number Of Adult Returns To The Tuolumne River
05/23/2001	065460	96,371	1,088,938	Wickland Oil	0
06/18/2002	062664	238,195	35,749	Wickland Oil	8.50
06/18/2002	062666	238,195	35,749	Wickland Oil	0
06/18/2002	062667	237,231	36,608	Wickland Oil	0
06/18/2002	062668	237,231	36,608	Wickland Oil	0
06/18/2002	062668	238,193	35,751	Wickland Oil	4.36

Tagged Mokelumne Hatchery Releases in San Joaquin Delta					
Release Date	Cwt Number	Number Of Tagged Fish Releases	Number Of Untagged Fish Released	Release Location	Estimated Number Of Adult Returns To The Tuolumne River
10/01/1976	060205	25,059	511	Brannan Island	0
02/01/1977	060206	26,912	1,995	Brannan Island	0
09/28/1977	064807	32,915	3,985	Brannan Island	0
10/01/1979	064812	43,370	0	Rio Vista	0
05/10/1994	064803	53,606	487	Thornton	0
05/10/1994	064804	49,864	352	Thornton	0
05/23/1994	064801	51,314	414	Thornton	4.14
05/23/1994	064801	51,314	414	Thornton	6.82
05/23/1994	064802	51,518	415	Thornton	0
04/18/1995	060211	48,345	4,898	Thornton	0
04/18/1995	060212	49,531	5,019	Thornton	4.52
04/25/1995	060213	49,837	4,511	Thornton	0
04/25/1995	060214	49,625	4,492	Thornton	0
05/15/1995	060210	51,757	719,462	Thornton	0
05/15/1996	060216	49,946	3,415	Thornton	0
05/15/1996	060217	52,123	1,282	Thornton	0
05/20/1996	060218	50,832	1,898	Jersey Point	4.26
05/20/1996	060218	50,832	1,898	Jersey Point	7.19
05/20/1996	060218	50,832	1,898	Jersey Point	0
05/20/1996	060219	52,389	636	Jersey Point	8.31
04/30/1997	064912	52,022	0	Jersey Point	0
04/30/1997	064913	51,978	130	Jersey Point	0
04/28/1998	060234	51,227	1,046	Jersey Point	0
04/28/1998	060235	52,127	1,065	Jersey Point	0
05/21/1999	054115	49,740	860	Sherman Island	0
05/21/1999	060247	51,366	2,140	Sherman Island	4.16
05/21/1999	060248	49,740	860	Sherman Island	4.07
05/21/1999	064920	25,162	514	Sherman Island	8.16

Tagged Mokelumne Hatchery Releases in San Joaquin Delta					
Release Date	Cwt Number	Number Of Tagged Fish Releases	Number Of Untagged Fish Released	Release Location	Estimated Number Of Adult Returns To The Tuolumne River
05/21/1999	064921	25,200	514	Sherman Island	0
05/21/1999	064922	25,121	513	Sherman Island	4.08
05/21/1999	064923	25,579	522	Sherman Island	4.08
05/01/2000	055113	50,445	1,560	Sherman Island	0
05/01/2000	060248	51,167	867	Sherman Island	0
05/01/2000	060253	50,445	1,560	Sherman Island	20.60
05/01/2000	060254	51,167	867	Sherman Island	16.26
04/24/2001	060268	51,207	206	Jersey Point	11.14
04/24/2001	060269	51,746	0	Jersey Point	3.70
04/24/2001	060270	51,207	206	Jersey Point	4.01
04/24/2001	060271	51,746	0	Jersey Point	3.79
04/24/2001	060271	51,746	0	Jersey Point	19.98
04/26/2001	062675	25,384	128	West Sacramento	3.72
04/26/2001	062677	25,872	130	West Sacramento	0
04/26/2001	062716	25,384	128	West Sacramento	0
04/26/2001	062717	25,872	130	West Sacramento	4.02
05/09/2001	062708	25,201	1,009	West Sacramento	0
05/09/2001	062709	24,527	982	West Sacramento	0
04/09/2002	062716	25,661	259	Jersey Point	0
04/09/2002	062717	25,600	0	Jersey Point	0
04/09/2002	062722	25,661	259	Jersey Point	0
04/09/2002	062723	25,600	0	Jersey Point	18.97
04/23/2002	064453	25,500	0	Jersey Point	11.38
04/23/2002	065459	25,245	255	Jersey Point	0
04/23/2002	065863	25,245	255	Jersey Point	15.33
10/07/2002	064930	25,981	0	Sherman Island	7.59
10/08/2002	060277	50,387	253	Beaver Slough,	0
10/15/2002	064931	25,811	261	Sherman Island	3.83
10/23/2002	064928	25,240	127	Sherman Island	15.25
10/30/2002	064929	25,912	130	Sherman Island	11.44

Tagged Mokelumne Hatchery Releases in the San Francisco Bay					
Release Date	Cwt Number	Number Of Tagged Fish Releases	Number Of Untagged Fish Released	Release Location	Estimated Number Of Adult Returns To The Tuolumne River
04/12/1995	060208	49,769	1,912	Crockett	3.60
05/22/1995	060208	49,769	1,912	Crockett	0
06/06/1996	060229	52,704	745,388	Rodeo Minor Port	0
06/02/1997	060230	50,235	948,965	Rodeo Minor Port	0

Tagged Mokelumne Hatchery Releases in the San Francisco Bay					
Release Date	Cwt Number	Number Of Tagged Fish Releases	Number Of Untagged Fish Released	Release Location	Estimated Number Of Adult Returns To The Tuolumne River
06/12/1998	060240	51,059	352,416	Carquinez Strait	65.33
06/12/1998	060241	51,427	352,426	Carquinez Strait	64.92
06/15/1999	060215	95,203	782,097	Crockett	0
05/08/2000	060250	51,389	437,894	Wickland Oil	76.10
05/08/2000	060251	51,765	438,256	Wickland Oil	75.66
04/27/2001	062706	25,550	128	Benicia	0

Tagged Merced Hatchery Releases in the Merced River					
Release Date	Cwt Number	Number Of Tagged Fish Releases	Number Of Untagged Fish Released	Release Location	Estimated Number Of Adult Returns To The Tuolumne River
10/01/1978	064610	49,498	1,113	MRH	0
09/26/1979	064611	16,059	874	Gallo	0
10/15/1981	064612	40,760	15,445	Gallo	0
04/22/1982	064617	49,217	2,590	Gallo	0
11/10/1982	064626	23,804	36,756	MRH	0
11/10/1982	064627	23,804	25,636	MRH	0
10/01/1983	064629	41,143	8,857	MRH	0
10/19/1984	064638	49,649	1,273	Gallo	0
10/17/1985	064644	35,535	33,660	Gallo	0
11/10/1982	0601110101	25,357	72,217	Merced River	0
11/10/1982	0601110102	25,276	1,786	Merced River	0
11/14/1991	064512	29,653	1,681	MRH	0
11/14/1991	064513	29,653	1,681	MRH	0
11/14/1991	064514	29,653	1,681	MRH	0
03/04/1992	064515	22,815	12,210	Merced River	9.59
02/18/1993	064651	14,946	1,850	MRH	2.24
02/18/1993	064651	14,946	1,850	MRH	3.13
02/18/1993	064651	14,946	1,850	MRH	35.10
11/05/1993	064517	35,064	283	MRH	2.01
11/05/1993	064518	13,145	106	MRH	3.71
11/05/1993	064620	521	4	MRH	0
11/05/1993	064621	2,364	19	MRH	0
11/12/1993	064516	32,891	265	MRH	0
11/12/1993	064517	35,064	283	MRH	0
04/22/1994	0601020112	48,943	2,576	MRH	0
04/22/1994	0601110210	24,946	252	MRH	3.72
04/22/1994	0601110210	24,946	252	MRH	6.84
04/22/1994	0601110211	24,946	252	MRH	3.72
04/22/1994	0601110212	24,946	252	MRH	0
04/22/1994	0601110213	24,946	252	MRH	3.72
04/22/1994	0601110214	24,349	701	Merced River	0
04/22/1994	0601110215	27,349	701	Merced River	0

Tagged Merced Hatchery Releases in the Merced River					
Release Date	Cwt Number	Number Of Tagged Fish Releases	Number Of Untagged Fish Released	Release Location	Estimated Number Of Adult Returns To The Tuolumne River
	0601110301	27,349	701	Merced River	0
11/17/1994	0601020112	48,943	2,576	MRH	7.12
11/17/1994	0601020112	48,943	2,576	MRH	7.74
11/17/1994	064624	10,021	528	MRH	7.74
11/17/1994	064625	8,904	469	MRH	2.10
11/28/1994	0601020111	48,889	5,241	Merced River	0
11/28/1994	064516	32,891	265	MRH	2.01
11/28/1994	064622	7,600	458	Merced River	0
11/28/1994	064623	7,586	458	Merced River	0
05/03/1995	0601110401	28,349	579	MRH	3.75
05/03/1995	0601110401	28,349	579	MRH	62.15
05/03/1995	0601110402	27,961	571	MRH	7.51
05/03/1995	0601110402	27,961	571	MRH	27.62
05/03/1995	0601110403	26,839	548	MRH	6.91
05/03/1995	0601110404	28,141	574	MRH	4.19
05/03/1995	0601110404	28,141	574	MRH	7.51
05/03/1995	0601110404	28,141	574	MRH	20.72
05/04/1995	0601110402	27,961	571	MRH	0
05/04/1995	0601110405	27,317	1,066	Merced River	4.27
05/04/1995	0601110405	27,317	1,066	Merced River	15.29
05/04/1995	0601110405	27,317	1,066	Merced River	42.19
05/04/1995	0601110406	27,642	1,079	Hatfield State Park	4.27
05/04/1995	0601110406	27,642	1,079	Hatfield State Park	15.29
05/04/1995	0601110406	27,642	1,079	Hatfield State Park	42.19
05/04/1995	0601110407	28,052	1,095	Hatfield State Park	15.29
05/04/1995	0601110407	28,052	1,095	Hatfield State Park	49.22
04/25/1996	0601110410	22,637	4,902	MRH	0
04/25/1996	0601110411	21,691	1,698	MRH	0
04/26/1996	0601110504	22,018	4,768	Merced River	0
04/26/199	0601110505	20,613	4,464	Merced River	0
04/20/1997	0601110511	26,045	3,131	MRH	0
04/20/1997	0601110512	27,683	3,316	MRH	0
04/20/1997	0601110513	31,930	3,828	MRH	0
04/20/1997	0601110514	24,880	2,969	MRH	0
04/22/1997	0601110515	24,398	5,495	Hatfield State Park	0
04/22/1997	0601110601	29,011	6,547	Hatfield State Park	0
04/22/1997	0601110602	25,761	5,817	Hatfield State Park	0
04/22/1997	0601110603	25,317	5,705	Hatfield State Park	0
05/14/1997	0601110614	33,064	4,511	MRH	0
05/14/1997	0601110615	28,294	3,861	Hatfield State Park	0
05/14/1997	0601110702	5,856	796	Hatfield State Park	0
04/12/1998	062520	27,973	1,664	MRH	3.67
04/12/1998	064523	35,800	2,129	MRH	3.67
04/12/1998	064524	36,289	2,158	MRH	17.52

Tagged Merced Hatchery Releases in the Merced River					
Release Date	Cwt Number	Number Of Tagged Fish Releases	Number Of Untagged Fish Released	Release Location	Estimated Number Of Adult Returns To The Tuolumne River
04/14/1998	062521	34,805	5,872	Hatfield State Park	5.68
04/14/1998	062521	34,805	5,872	Hatfield State Park	8.10
04/14/1998	062522	30,857	5,206	Hatfield State Park	8.10
04/14/1998	062522	30,857	5,206	Hatfield State Park	38.65
04/14/1998	062523	8,447	1,425	Hatfield State Park	0
05/03/1998	0601110709	28,248	257	MRH	16.68
05/03/1998	0601110710	25,482	232	MRH	9.80
05/03/1998	0601110711	25,220	230	MRH	7.00
05/03/1998	0601110711	25,220	230	MRH	9.80
05/03/1998	0601110712	25,046	228	MRH	0
05/04/1998	0601110710	25,482	232	MRH	25.03
05/04/1998	0601110711	25,220	230	MRH	0
05/05/1998	0601110502	49,873	866	Hatfield State Park	4.94
05/05/1998	0601110502	49,873	866	Hatfield State Park	33.64
05/05/1998	0601110713	25,314	439	Hatfield State Park	4.94
05/05/1998	0601110713	25,314	439	Hatfield State Park	7.05
05/05/1998	0601110713	25,314	439	Hatfield State Park	33.64
05/05/1998	0601110801	25,923	1,198	MRH	0
05/05/1998	0601110802	23,868	1,103	MRH	0
04/14/1999	064528	25,462	628	MRH	0
04/14/1999	064529	25,445	628	MRH	0
04/14/1999	064530	25,221	622	MRH	0
04/16/1999	064531	24,123	1,493	Hatfield State Park	25.79
04/16/1999	064532	24,640	1,525	Hatfield State Park	4.24
04/16/1999	064532	24,640	1,525	Hatfield State Park	5.16
05/05/1999	0601110714	24,075	1,112	MRH	0
05/05/1999	0601110801	25,923	1,198	MRH	0
05/05/1999	0601110802	23,868	1,103	MRH	0
05/05/1999	0601110803	23,936	1,106	MRH	4.18
05/07/1999	064534	24,337	2,390	Hatfield State Park	0
05/07/1999	064535	23,215	2,281	Hatfield State Park	5.33
05/07/1999	064536	23,436	2,302	Hatfield State Park	0
04/12/2000	064487	25,507	869	Snelling	0
04/12/2000	064488	25,318	862	Snelling	0
04/12/2000	064539	25,313	862	Snelling	0
04/12/2000	064540	25,395	865	Snelling	0
04/12/2000	064541	24,490	1,369	Hatfield State Park	0
04/12/2000	064542	24,432	1,366	Hatfield State Park	0
04/12/2000	064543	24,525	1,371	Hatfield State Park	0
04/12/2000	064544	24,490	1,369	Hatfield State Park	0
04/12/2000	064545	24,432	1,366	Hatfield State Park	0
04/27/2000	064552	26,189	0	Hatfield State Park	0
04/27/2000	064553	25,794	0	Hatfield State Park	11.99
04/27/2000	064554	26,189	0	Hatfield State Park	0

Tagged Merced Hatchery Releases in the Merced River					
Release Date	Cwt Number	Number Of Tagged Fish Releases	Number Of Untagged Fish Released	Release Location	Estimated Number Of Adult Returns To The Tuolumne River
	064555	25,444	0	Hatfield State Park	4.00
04/28/2000	064549	25,794	0	Hatfield State Park	0
04/21/2001	064412	25,029	908	MRH	3.83
04/21/2001	064414	24,077	873	MRH	7.66
04/21/2001	064415	24,342	883	MRH	0
04/21/2001	064416	24,034	872	MRH	3.83
04/21/2001	064417	24,342	883	MRH	0
04/21/2001	064418	24,034	872	MRH	0
04/23/2001	064419	24,925	483	Hatfield State Park	0
04/26/2001	064417	24,925	483	Hatfield State Park	0
04/26/2001	064418	24,958	483	Hatfield State Park	0
04/26/2001	064419	24,885	482	Hatfield State Park	0
04/26/2001	064420	24,958	483	Hatfield State Park	0
04/26/2001	064421	24,885	482	Hatfield State Park	0
05/08/2001	064420	24,722	479	MRH	0
05/08/2001	064421	24,121	467	MRH	0
05/08/2001	064422	24,722	479	MRH	0
05/08/2001	064424	25,972	503	MRH	0
05/10/2001	052418	24,401	1,017	Merced River	7.70
05/11/2001	064423	23,038	2,195	Hatfield State Park	0
05/11/2001	064424	23,227	2,213	Hatfield State Park	0
05/11/2001	064426	23,428	164,233	MRH	0
05/11/2001	064427	23,227	2,213	Hatfield State Park	0
05/11/2001	064428	23,428	164,233	MRH	0
04/03/2002	064443	24,380	1,065	Hatfield State Park	19.29
04/03/2002	064444	24,228	1,059	Hatfield State Park	19.30
04/03/2002	064451	24,380	1,065	Hatfield State Park	0
04/03/2002	064548	24,890	1,087	Hatfield State Park	0
04/05/2002	064544	24,890	1,087	Hatfield State Park	0
04/21/2002	064484	23,140	2,449	MRH	0
04/21/2002	064485	22,183	2,347	MRH	0
04/26/2002	064480	23,363	2,010	Hatfield State Park	0
04/26/2002	064481	23,639	2,033	Hatfield State Park	0
04/26/2002	064486	23,349	2,009	Hatfield State Park	0
04/26/2002	064487	23,363	2,010	Hatfield State Park	0
04/26/2002	064488	23,639	2,033	Hatfield State Park	0
04/13/2003	064489	22,677	3,389	MRH	0
04/13/2003	064490	22,817	3,409	MRH	0
04/13/2003	064491	22,945	3,429	MRH	0
04/13/2003	064492	21,725	3,246	MRH	0
04/16/2003	064493	23,274	1,883	Hatfield State Park	3.07
04/16/2003	064493	23,274	1,883	Hatfield State Park	4.10
04/16/2003	064494	23,872	1,932	Hatfield State Park	0
04/16/2003	064495	23,833	1,929	Hatfield State Park	0

Tagged Merced Hatchery Releases in the Merced River					
Release Date	Cwt Number	Number Of Tagged Fish Releases	Number Of Untagged Fish Released	Release Location	Estimated Number Of Adult Returns To The Tuolumne River
04/25/2003	064496	24,231	1,539	MRH	0
04/25/2003	064498	23,758	1,508	MRH	0
04/29/2003	064564	24,544	1,023	Hatfield State Park	0
04/29/2003	064565	24,484	1,020	Hatfield State Park	0
04/29/2003	064566	24,358	1,015	Hatfield State Park	2.96
04/29/2003	064566	24,358	1,015	Hatfield State Park	3.95
05/04/2003	062777	23,591	1,892	MRH	0
05/04/2003	062778	23,862	1,914	MRH	0
05/04/2003	064449	23,512	1,886	MRH	0
05/04/2003	064450	24,330	1,952	MRH	0
05/07/2003	064546	22,605	2,937	Hatfield State Park	0
05/07/2003	064547	22,715	2,952	Hatfield State Park	0
05/07/2003	064572	22,650	2,943	Hatfield State Park	0
04/20/2004	064595	23,038	2,588	Hatfield State Park	0
04/28/2004	064667	25,306	649	Hatfield State Park	0
05/09/2004	064669	24,418	755	MRH	0
05/12/2004	064599	24,769	900	Hatfield State Park	0

Table 3. The number of unmarked hatchery juveniles produced in the Feather and Nimbus hatcheries that were released in the San Francisco Bay, Mokelumne hatchery that were released in the San Joaquin Delta and San Francisco Bay, and Merced hatchery that were released in the Merced River from 1978 to 2004. The estimated total numbers of adult returns to the Tuolumne River from these unmarked releases are presented in the columns identified as "Unmarked Adults" in Table 1.

Untagged Feather River Hatchery Releases in the San Francisco Bay. Mean Return Rate to the Tuolumne River = 0.00540%			
Release Date	Release Location	Number Released	Estimated Number Of Adult Returns To The Tuolumne River
06/01/1978	Tiburon Net Pens	150,500	8.1
07/01/1979	Bodega Bay	12,040	0.6
08/01/1979	Tiburon Net Pens	35,950	1.9
07/01/1980	Carquinez Strait	42,000	2.3
05/01/1981	Benicia	793,981	42.8
06/01/1981	Benicia	282,300	15.2
06/01/1981	Benicia	1,057,300	57.1
07/01/1981	Benicia	814600	44.0
08/01/1981	Benicia	343,850	18.6
09/01/1981	Benicia	190,510	10.3
04/01/1982	Benicia	860,900	46.5
05/01/1982	Benicia	110,220	5.9
05/01/1982	Benicia	498,930	26.9

Untagged Feather River Hatchery Releases in the San Francisco Bay. Mean Return Rate to the Tuolumne River = 0.00540%			
Release Date	Release Location	Number Released	Estimated Number Of Adult Returns To The Tuolumne River
06/01/1982	Benicia	1,220,200	65.8
07/01/1982	Benicia	173,600	9.4
08/01/1982	Benicia	256,425	13.8
09/01/1982	Benicia	9,600	0.5
09/01/1982	Benicia	24,700	1.3
02/01/1983	Feather River	2,558,400	138.1
06/01/1983	Benicia	743,200	40.1
07/01/1983	Benicia	599,700	32.4
07/01/1983	Tiburon Net Pens	49,300	2.7
07/01/1983	Vallejo	48,600	2.6
08/01/1983	Tiburon Net Pens	48,000	2.6
08/01/1983	Vallejo	44,800	2.4
09/01/1983	Vallejo	42,700	2.3
10/01/1983	Tiburon Net Pens	21,000	1.1
10/01/1983	Tiburon Net Pens	23,200	1.3
06/01/1984	Benicia	63,000	3.4
06/01/1984	Vallejo	42,750	2.3
06/01/1984	Port Chicago	44,100	2.4
07/01/1984	Benicia	634,550	34.2
08/01/1984	Berkeley Marina	230,200	12.4
08/01/1984	Benicia	1,051,175	56.7
09/01/1984	Berkeley Marina	100,200	5.4
09/01/1984	Benicia	476,650	25.7
01/01/1985	Feather River	182,400	9.8
04/01/1985	Benicia	943,050	50.9
05/01/1985	Feather River	22,000	1.2
05/01/1985	Benicia	465,500	25.1
05/01/1985	Benicia	479,077	25.9
05/01/1985	Port Chicago	53,100	2.9
05/01/1985	Berkeley Marina	52,700	2.8
06/01/1985	Tiburon Net Pens	28,500	1.5
06/01/1985	Benicia	465,500	25.1
07/01/1985	Benicia	2,412,575	130.2
08/01/1985	Benicia	2,190,825	118.2
09/01/1985	Benicia	1,718,380	92.7
10/01/1985	Benicia	112,800	6.1
04/01/1986	Feather River	14,400	0.8
05/01/1986	Feather River	8,400	0.5
05/01/1986	Benicia	573,750	31.0
06/01/1986	Benicia	313,200	16.9
06/01/1986	Tiburon Net Pens	50,000	2.7
07/01/1986	Benicia	1,136,800	61.3
08/01/1986	San Francisco Bay	1,829,275	98.7
09/01/1986	San Francisco Bay	686,150	37.0

Untagged Feather River Hatchery Releases in the San Francisco Bay. Mean Return Rate to the Tuolumne River = 0.00540%			
Release Date	Release Location	Number Released	Estimated Number Of Adult Returns To The Tuolumne River
10/01/1986	Feather River	1,451,450	78.3
04/01/1987	Benicia	821,300	44.3
05/01/1987	Benicia	926,500	50.0
06/01/1987	Benicia	2,382,800	128.6
07/01/1987	Benicia	2,477,075	133.7
08/01/1987	Benicia	1,860,400	100.4
09/01/1987	Benicia	435,850	23.5
03/01/1988	Benicia	129,200	7.0
04/01/1988	Benicia	827,600	44.7
05/01/1988	Benicia	704,850	38.0
06/01/1988	Tiburon Net Pens	50,050	2.7
06/01/1988	Benicia	1,525,450	82.3
07/01/1988	Benicia	2,701,750	145.8
12/01/1988	Feather River	538,400	29.1
01/01/1989	Feather River	371,800	20.1
04/01/1989	Benicia	685,500	37.0
05/01/1989	Benicia	537,000	29.0
06/01/1989	Benicia	972,100	52.5
06/01/1989	Tiburon Net Pens	43,500	2.3
07/01/1989	Benicia	911,400	49.2
08/01/1989	Benicia	1,075,900	58.1
05/01/1990	Benicia	882,000	47.6
06/01/1990	Benicia	3,414,050	184.2
07/01/1990	Benicia	1,214,800	65.6
08/01/1990	Benicia	1,449,650	78.2
09/01/1990	Benicia	549,200	29.6
05/01/1991	Tiburon Net Pens	55,900	3.0
01/01/1992	Feather River	1,400,000	75.5
03/01/1992	Feather River	1,655,440	89.3
04/01/1992	Monterey	35,000	1.9
04/01/1992	Feather River	768,995	41.5
05/01/1992	Benicia	465,500	25.1
05/01/1992	Monterey	59,850	3.2
05/01/1992	Monterey	26,500	1.4
05/01/1992	Ventura	4,600	0.2
05/01/1992	Benicia	1,173,850	63.3
06/01/1992	Benicia	1,314,900	71.0
07/01/1992	Benicia	1,634,100	88.2
08/01/1992	Benicia	1,186,400	64.0
09/01/1992	Benicia	443,100	23.9
10/01/1992	Benicia	276,160	14.9
01/01/1993	Feather River	1,920,000	103.6
02/01/1993	Feather River	160,000	8.6
05/01/1993	Tiburon Net Pens	54,000	2.9

Untagged Feather River Hatchery Releases in the San Francisco Bay. Mean Return Rate to the Tuolumne River = 0.00540%			
Release Date	Release Location	Number Released	Estimated Number Of Adult Returns To The Tuolumne River
05/01/1993	Monterey	77,400	4.2
05/01/1993	Benicia	1,836,000	99.1
06/01/1993	Benicia	3,077,270	166.1
07/01/1993	Benicia	1,848,518	99.7
12/01/1993	Feather River	264,000	14.2
01/01/1994	Feather River	4,995,200	269.5
03/01/1994	Feather River	120,000	6.5
04/01/1994	Benicia	712,642	38.5
05/01/1994	Benicia	2,632,217	142.0
06/01/1994	Monterey	24,000	1.3
06/01/1994	Tiburon Net Pens	51,150	2.8
06/01/1994	Benicia	1,548,320	83.5
07/01/1994	Benicia	250,400	13.5
07/01/1994	Wickland Oil	518,300	28.0
07/01/1994	Unocal	627,000	33.8
01/01/1995	Feather River	674,786	36.4
02/01/1995	Feather River	3,142,258	169.6
03/01/1995	Feather River	219,200	11.8
03/01/1995	Feather River	750,075	40.5
04/01/1995	Benicia	269,152	14.5
05/01/1995	Unocal	103,400	5.6
05/01/1995	Benicia	396,952	21.4
05/01/1995	Wickland Oil	593,080	32.0
05/01/1995	Feather River	200,007	10.8
06/01/1995	Oceangraph Center	47,600	2.6
06/01/1995	Unocal	89,700	4.8
06/01/1995	Benicia	225,100	12.1
06/01/1995	Wickland Oil	907,432	49.0
07/01/1995	Wickland Oil	179,400	9.7
07/01/1995	Wickland Oil	1,365,575	73.7
01/01/1996	Feather River	156,000	8.4
03/01/1996	Feather River	652,000	35.2
04/01/1996	Wickland Oil	388,700	21.0
04/01/1996	Benicia	556,400	30.0
05/01/1996	Montezuma Slough	24,986	1.3
05/01/1996	Montezuma Slough	24,990	1.3
05/01/1996	Montezuma Slough	24,999	1.3
05/01/1996	Feather River	25,000	1.3
05/01/1996	Unocal	126,500	6.8
05/01/1996	Wickland Oil	527,850	28.5
05/01/1996	Benicia	545,100	29.4
06/01/1996	Wickland Oil	24,000	1.3
06/01/1996	Tiburon Net Pens	49,400	2.7
06/01/1996	Wickland Oil	179,200	9.7

Untagged Feather River Hatchery Releases in the San Francisco Bay. Mean Return Rate to the Tuolumne River = 0.00540%			
Release Date	Release Location	Number Released	Estimated Number Of Adult Returns To The Tuolumne River
07/01/1996	Wickland Oil	48,000	2.6
07/01/1996	Unocal	73,364	4.0
07/01/1996	Wickland Oil	96,000	5.2
07/01/1996	Wickland Oil	146,728	7.9
07/01/1996	Wickland Oil	147,200	7.9
07/01/1996	Wickland Oil	184,000	9.9
07/01/1996	Wickland Oil	202,400	10.9
07/01/1996	Wickland Oil	213,900	11.5
07/01/1996	Wickland Oil	282,900	15.3
07/01/1996	Wickland Oil	345,904	18.7
07/01/1996	Wickland Oil	460,000	24.8
07/01/1996	Wickland Oil	635,652	34.3
05/01/1997	Benicia	25,200	1.4
05/01/1997	Wickland Oil	36,830	2.0
05/01/1997	Tiburon Net Pens	52,650	2.8
05/01/1997	Monterey	58,000	3.1
06/01/1997	Wickland Oil	55,000	3.0
06/01/1997	Moss Landing	60,140	3.2
06/01/1997	Bennett's Marina	62,100	3.4
06/01/1997	Benicia	66,700	3.6
06/01/1997	Wickland Oil	67,500	3.6
06/01/1997	Port San Lucas	71,300	3.8
06/01/1997	Benicia	80,500	4.3
06/01/1997	Bennett's Marina	93,800	5.1
06/01/1997	Benicia	105,300	5.7
06/01/1997	Benicia	121,900	6.6
06/01/1997	Wickland Oil	131,100	7.1
06/01/1997	Bennett's Marina	135,700	7.3
06/01/1997	Wickland Oil	168,200	9.1
06/01/1997	Benicia	177,100	9.6
06/01/1997	Wickland Oil	210,600	11.4
06/01/1997	Wickland Oil	222,400	12.0
06/01/1997	Wickland Oil	239,200	12.9
06/01/1997	Wickland Oil	393,600	21.2
06/01/1997	Wickland Oil	487,600	26.3
06/01/1997	Wickland Oil	542,800	29.3
07/01/1997	Wickland Oil	55,200	3.0
07/01/1997	Bennett's Marina	78,200	4.2
07/01/1997	Wickland Oil	115,000	6.2
07/01/1997	Wickland Oil	156,400	8.4
07/01/1997	Wickland Oil	188,600	10.2
07/01/1997	Bennett's Marina	218,400	11.8
07/01/1997	Wickland Oil	297,250	16.0
07/01/1997	Wickland Oil	326,600	17.6

Untagged Feather River Hatchery Releases in the San Francisco Bay. Mean Return Rate to the Tuolumne River = 0.00540%			
Release Date	Release Location	Number Released	Estimated Number Of Adult Returns To The Tuolumne River
07/01/1997	Wickland Oil	345,000	18.6
07/01/1997	Wickland Oil	384,100	20.7
07/01/1997	Wickland Oil	407,100	22.0
07/01/1997	Wickland Oil	806,400	43.5
07/01/1997	Wickland Oil	95,800	5.2
05/01/1998	Wickland Oil	2,392,200	129.1
06/01/1998	Wickland Oil	388,800	21.0
06/01/1998	Wickland Oil	411,700	22.2
06/01/1998	Wickland Oil	443,400	23.9
05/01/1999	San Francisco Bay	791,670	42.7
06/01/1999	San Francisco Bay	845,725	45.6
06/01/1999	San Francisco Bay	1,780,858	96.1
06/01/1999	San Francisco Bay	2,307,282	124.5
05/01/2000	Monterey	182,850	9.9
05/01/2000	San Francisco Bay	478,180	25.8
05/01/2000	San Francisco Bay	959,850	51.8
05/01/2000	San Francisco Bay	1,971,010	106.4
06/01/2000	San Francisco Bay	74,100	4.0
06/01/2000	Benicia	486,100	26.2
06/01/2000	San Francisco Bay	1,467,050	79.2
04/01/2001	Shore Terminal	170,200	9.2
04/01/2001	Shore Terminal	397,900	21.5
05/01/2001	Benicia	60,000	3.2
05/01/2001	Benicia	80,500	4.3
05/01/2001	Monterey	107,810	5.8
05/01/2001	Benicia	1,566,350	84.5
05/01/2001	Benicia	491,500	26.5
06/01/2001	Benicia	487,600	26.3
03/01/2002	Benicia	162,800	8.8
04/01/2002	Benicia	2,773,538	149.7
05/01/2002	Benicia	117,200	6.3
05/01/2002	Monterey	120,000	6.5
05/01/2002	Benicia	1,283,800	69.3
06/01/2002	Benicia	422,050	22.8
05/01/2003	Benicia	54,000	2.9
05/01/2003	Bennett's Marina	904,000	48.8
05/01/2003	Benicia	1,320,700	71.3
05/01/2003	Benicia	968,900	52.3
06/01/2003	Benicia	8,360	0.5
06/01/2003	San Francisco Bay	133,400	7.2
06/01/2003	Benicia	531,000	28.7
06/01/2003	Benicia	1,163,800	62.8
05/01/2004	Benicia	589,788	31.8
05/01/2004	Benicia	3,436,200	185.4

Untagged Feather River Hatchery Releases in the San Francisco Bay. Mean Return Rate to the Tuolumne River = 0.00540%			
Release Date	Release Location	Number Released	Estimated Number Of Adult Returns To The Tuolumne River
06/01/2004	Benicia	854,800	46.1
06/01/2004	Benicia	2,377,800	128.3
08/01/1988	Benicia	1,595,220	86.1
09/01/1988	Benicia	109,000	5.9
08/01/1993	Benicia	2,615,660	141.1
09/01/1993	Benicia	309,500	16.7

Untagged Nimbus Hatchery Releases in the San Francisco Bay. Mean Return Rate to the Tuolumne River = 0.00157%			
Release Date	Release Location	Number Released	Estimated Number Of Adult Returns To The Tuolumne River
09/01/1980	Benicia	270281	4.26
04/01/1981	Benicia	335699	5.29
04/01/1981	Pittsburg	1536048	24.19
05/01/1981	Benicia	877820	13.82
06/01/1981	Benicia	60550	0.95
06/01/1981	Benicia	1276700	20.10
07/01/1981	Benicia	1739360	27.39
07/01/1982	Benicia	1458625	22.97
08/01/1982	Benicia	1457905	22.96
12/01/1982	Cosumnes River	599040	9.43
04/01/1983	Benicia	615000	9.68
04/01/1983	Vallejo	1012500	15.94
05/01/1983	Benicia	391400	6.16
06/01/1983	Benicia	87000	1.37
06/01/1983	Benicia	516300	8.13
07/01/1983	Benicia	1915200	30.16
08/01/1983	Benicia	49940	0.79
08/01/1983	Berkeley Marina	50000	0.79
08/01/1983	Port Chicago	50350	0.79
05/01/1984	Benicia	180000	2.83
06/01/1984	Benicia	862650	13.58
07/01/1984	Fort Baker	50600	0.80
07/01/1984	Berkeley Marina	50675	0.80
07/01/1984	Port Chicago	50710	0.80
07/01/1984	Benicia	2826300	44.50
05/01/1985	Benicia	228500	3.60
05/01/1985	Benicia	463900	7.30
06/01/1985	Benicia	1027100	16.17
06/01/1985	Benicia	1960600	30.87
07/01/1985	Berkeley Marina	25500	0.40
07/01/1985	Benicia	846100	13.32
05/01/1986	Benicia	209300	3.30
05/01/1986	Benicia	288490	4.54

Untagged Nimbus Hatchery Releases in the San Francisco Bay. Mean Return Rate to the Tuolumne River = 0.00157%			
Release Date	Release Location	Number Released	Estimated Number Of Adult Returns To The Tuolumne River
06/01/1986	Benicia	2850750	44.89
07/01/1986	Benicia	1717270	27.04
05/01/1987	Benicia	492000	7.75
05/01/1987	Benicia	818975	12.90
06/01/1987	Benicia	372600	5.87
06/01/1987	Benicia	2221400	34.98
07/01/1987	Benicia	375150	5.91
05/01/1988	Benicia	264000	4.16
06/01/1988	Benicia	1364200	21.48
06/01/1988	Benicia	2130400	33.54
07/01/1988	Benicia	182200	2.87
07/01/1988	Benicia	398500	6.27
06/01/1989	Benicia	1789517	28.18
07/01/1989	Benicia	2629870	41.41
05/01/1990	Benicia	338800	5.33
06/01/1990	Benicia	376200	5.92
06/01/1990	Benicia	2714150	42.74
07/01/1990	Benicia	1001650	15.77
03/01/1991	Cosumnes River	97920	1.54
05/01/1991	Benicia	1029300	16.21
06/01/1991	Benicia	791000	12.45
06/01/1991	Benicia	801700	12.62
07/01/1991	Benicia	443100	6.98
05/01/1992	Benicia	2664950	41.96
06/01/1992	Benicia	1557000	24.52
07/01/1992	Benicia	177200	2.79
02/01/1993	Cosumnes River	200380	3.16
07/01/1993	Unocal	110000	1.73
07/01/1993	Benicia	490600	7.72
07/01/1993	Wickland Oil	639800	10.07
01/01/1994	Cosumnes River	206800	3.26
06/01/1994	Unocal	78000	1.23
06/01/1994	Benicia	1565900	24.66
06/01/1994	Wickland Oil	2509100	39.51
07/01/1994	Benicia	36600	0.58
02/01/1995	Cosumnes River	200720	3.16
06/01/1995	Unocal	484000	7.62
06/01/1995	Benicia	874450	13.77
06/01/1995	Wickland Oil	973650	15.33
07/01/1995	Benicia	187000	2.94
07/01/1995	Unocal	204000	3.21
07/01/1995	Wickland Oil	1500600	23.63
05/01/1996	Unocal	253000	3.98
05/01/1996	Benicia	538600	8.48
05/01/1996	Wickland Oil	1078600	16.98
06/01/1996	Unocal	67200	1.06

Untagged Nimbus Hatchery Releases in the San Francisco Bay. Mean Return Rate to the Tuolumne River = 0.00157%			
Release Date	Release Location	Number Released	Estimated Number Of Adult Returns To The Tuolumne River
06/01/1996	Wickland Oil	200000	3.15
06/01/1996	Wickland Oil	884600	13.93
06/01/1996	Benicia	1008450	15.88
05/01/1997	Benicia	367600	5.79
05/01/1997	Wickland Oil	1003800	15.81
06/01/1997	Wickland Oil	283600	4.47
06/01/1997	Wickland Oil	336300	5.30
06/01/1997	Wickland Oil	2063500	32.49
04/01/1998	Monterey	60720	0.96
05/01/1998	Monterey	60200	0.95
05/01/1998	Monterey	70210	1.11
05/01/1998	Wickland Oil	108000	1.70
05/01/1998	Wickland Oil	264000	4.16
05/01/1998	Benicia	570400	8.98
06/01/1998	Tiburon Net Pens	52000	0.82
06/01/1998	Bennett's Marina	132000	2.08
06/01/1998	Wickland Oil	2693254	42.41
05/01/1999	Monterey	60200	0.95
05/01/1999	Monterey	61600	0.97
05/01/1999	Benicia	120000	1.89
05/01/1999	Wickland Oil	896900	14.12
06/01/1999	Tiburon Net Pens	52008	0.82
06/01/1999	Monterey	70000	1.10
06/01/1999	San Francisco Bay	217500	3.42
06/01/1999	Benicia	509208	8.02
06/01/1999	Wickland Oil	2741792	43.17
05/01/2000	Wickland Oil	129600	2.04
05/01/2000	Benicia	356200	5.61
05/01/2000	Wickland Oil	1605900	25.29
06/01/2000	Wickland Oil	144000	2.27
06/01/2000	Wickland Oil	1616000	25.44
05/01/2001	Monterey	142200	2.24
06/01/2002	Tiburon Net Pens	50400	0.79
06/01/2002	Monterey	60016	0.94
06/01/2002	Wickland Oil	576000	9.07
06/01/2002	Wickland Oil	1738800	27.38
07/01/2002	Wickland Oil	512000	8.06
07/01/2002	Wickland Oil	1224850	19.29
05/01/2003	Wickland Oil	480000	7.56
06/01/2003	Treasure Island USCG Station	502300	7.91
06/01/2003	Wickland Oil	994300	15.66
06/01/2003	Wickland Oil	2384700	37.55
08/01/1993	Benicia	362000	5.70
08/01/1993	Wickland Oil	604200	9.51

Untagged Mokelumne Hatchery Releases in the Sacramento River Delta. Mean Rates of Return to the Tuolumne River Wet Years, spring releases = 0.01148% Wet Years, fall releases = 0.01760% Dry Years, spring releases = 0.00507%			
Release Date	Release Location	Number Released	Estimated Number of Adult Returns to the Tuolumne River
11/01/1978	Rio Vista	9,076	1.60
11/01/1978	Rio Vista	93,000	16.36
01/01/1979	Rio Vista	30,000	3.44
01/01/1979	Rio Vista	45,000	5.17
10/01/1979	Rio Vista	174,200	30.65
11/01/1979	Rio Vista	19,167	3.37
10/01/1980	Rio Vista	194,250	34.18
10/01/1980	Rio Vista	478,500	84.19
11/01/1980	Rio Vista	38,500	6.77
11/01/1980	Rio Vista	50,000	8.80
12/01/1980	Rio Vista	12,100	2.13
12/01/1980	Rio Vista	13,200	2.32
12/01/1980	Rio Vista	15,400	2.71
11/01/1982	Rio Vista	6,050	1.06
11/01/1982	Rio Vista	152,880	26.90
11/01/1982	Rio Vista	170,765	30.05
11/01/1982	Rio Vista	186,450	32.81
12/01/1982	Rio Vista	40,000	7.04
10/01/1983	Rio Vista	337,500	59.38
10/01/1983	Rio Vista	367,500	64.66
06/01/1984	Thornton	15,250	1.75
04/01/1993	Tracy Pumping Plant	3,658	0.42
04/01/1993	Byron	15,000	1.72
05/01/1993	Tracy Pumping Plant	7,630	0.88
04/01/1998	Jersey Point	105,450	12.10
02/01/1999	Tracy Pumping Plant	500	0.06
03/01/1999	Tracy Pumping Plant	752	0.09
04/01/1999	Tracy Pumping Plant	744	0.09
05/01/1999	Tracy Pumping Plant	800	0.09
05/01/1999	Jersey Point	205,072	23.54
09/01/1999	Antioch Boat Ramp	9,600	1.10
10/01/1999	Antioch Boat Ramp	206,620	23.72
04/01/2000	Lighthouse Marina	52,632	6.04
05/01/2000	Jersey Point	104,039	11.94
11/01/1983	Rio Vista	25,200	4.43
11/01/1983	Rio Vista	27,440	4.83
10/01/1981	Rio Vista	51,940	2.63
10/01/1981	Rio Vista	212,803	10.79
11/01/1981	Rio Vista	220,500	11.18
11/01/1981	Rio Vista	366,405	18.57
12/01/1981	Rio Vista	56,200	2.85
10/09/1985	Rio Vista	27,300	1.38

04/01/1988	Clifton Court	18,000	0.91
05/01/1988	Clifton Court	19,250	0.98
03/01/1992	Clifton Court	5,100	0.26
04/01/1992	Byron	36,050	1.83
04/01/1992	Rio Vista	472,840	23.97
06/01/1994	Sacramento River	514,350	26.07
04/01/2001	Jersey Point	103,073	5.22
02/01/2002	Jersey Point	102,609	5.20
10/01/2002	Jersey Point	103,219	5.23
05/01/2003	Antioch Boat Ramp	575	0.03
04/01/2004	Thornton	4,000	0.20
04/01/2004	Thornton	1,009,700	51.18
05/01/2004	Clifton Court	3,000	0.15
05/01/2004	Thornton	2,488,857	126.15
06/01/2004	Thornton	210,800	10.68

Untagged Mokelumne Hatchery Releases in the San Francisco Bay. Mean Rates of Return to the Tuolumne River = 0.00622%			
Release Date	Release Location	Number Released	Estimated Number of Adult Returns to the Tuolumne River
08/13/1984	Benicia	42,000	2.61
08/13/1984	Benicia	56,350	3.51
08/14/1984	Benicia	42,000	2.61
08/14/1984	Benicia	63,250	3.94
08/15/1984	Benicia	48,000	2.99
08/15/1984	Benicia	64,400	4.01
08/16/1984	Benicia	51,600	3.21
08/16/1984	Benicia	69,230	4.31
08/17/1984	Benicia	52,200	3.25
08/17/1984	Benicia	70,035	4.36
08/20/1984	Benicia	33,750	2.10
08/20/1984	Benicia	42,500	2.64
08/21/1984	Benicia	20,250	1.26
08/21/1984	Benicia	25,500	1.59
06/25/1986	Benicia	50,400	3.14
06/26/1986	Benicia	56,000	3.48
06/27/1986	Benicia	66,000	4.11
07/01/1986	Benicia	1,000,400	62.24
08/01/1986	Benicia	39,600	2.46
08/01/1986	Berkeley Marina	170,100	10.58
09/01/1986	Bennett's Marina	50,600	3.15
09/01/1986	Benicia	191,500	11.91
05/01/1993	Benicia	437,500	27.22
06/01/1993	Benicia	1,547,500	96.28
07/01/1993	Benicia	1,026,600	63.87
05/01/1996	Benicia	983,494	61.19

Untagged Mokelumne Hatchery Releases in the San Francisco Bay. Mean Rates of Return to the Tuolumne River = 0.00622%			
Release Date	Release Location	Number Released	Estimated Number of Adult Returns to the Tuolumne River
06/01/1996	Benicia	850,700	52.93
04/01/1997	Benicia	254,200	15.82
05/01/1997	Benicia	636,000	39.57
06/01/1997	Benicia	858,000	53.38
07/01/1997	Wickland Oil	58,800	3.66
07/01/1997	Bennett's Marina	140,000	8.71
06/01/1998	Wickland Oil	453,500	28.22
07/01/1998	Wickland Oil	596,900	37.14
08/01/1998	Wickland Oil	144,900	9.02
06/01/1999	Wickland Oil	738,407	45.94
07/01/1999	Wickland Oil	440,200	27.39
10/01/1999	Wickland Oil	297,600	18.52
04/01/2000	Benicia	181,800	11.31
04/01/2000	Bennett's Marina	185,300	11.53
04/01/2000	Wickland Oil	463,700	28.85
05/01/2000	Wickland Oil	792,050	49.28
06/01/2000	Wickland Oil	642,925	40.00
09/11/1985	Benicia	24,000	1.49
09/12/1985	Benicia	24,000	1.49
09/16/1985	Benicia	26,000	1.62
09/17/1985	Benicia	23,100	1.44
09/18/1985	Benicia	23,100	1.44
09/19/1985	Benicia	27,300	1.70
09/20/1985	Benicia	13,000	0.81
09/24/1985	Benicia	13,300	0.83
09/25/1985	Benicia	27,930	1.74
09/26/1985	Benicia	48,400	3.01
09/27/1985	Benicia	46,200	2.87
09/30/1985	Benicia	33,600	2.09
10/01/1985	Benicia	51,200	3.19
10/02/1985	Benicia	100,800	6.27
10/03/1985	Benicia	103,700	6.45
10/04/1985	Benicia	159,800	9.94
10/07/1985	Benicia	92,400	5.75
10/08/1985	Benicia	93,800	5.84
10/09/1985	Benicia	59,800	3.72
10/10/1985	Benicia	74,100	4.61
10/11/1985	Benicia	28,600	1.78
10/17/1985	Benicia	24,200	1.51
10/18/1985	Benicia	35,200	2.19
10/21/1985	Benicia	44,200	2.75
10/22/1985	Benicia	42,000	2.61
04/01/1987	Benicia	601,665	37.43
05/01/1987	Benicia	398,700	24.81

Untagged Mokelumne Hatchery Releases in the San Francisco Bay. Mean Rates of Return to the Tuolumne River = 0.00622%			
Release Date	Release Location	Number Released	Estimated Number of Adult Returns to the Tuolumne River
06/01/1987	Benicia	208,050	12.94
06/01/1987	Benicia	259,900	16.17
06/01/1987	Bennett's Marina	391,100	24.33
07/01/1987	Benicia	135,050	8.40
07/01/1987	Mare Island	216,250	13.45
08/01/1987	Benicia	130,620	8.13
04/01/1988	Berkeley Marina	524,500	32.63
05/01/1988	Benicia	316,300	19.68
05/01/1988	Berkeley Marina	638,400	39.72
05/01/1988	Bennett's Marina	690,400	42.96
06/01/1988	Benicia	133,300	8.29
05/01/1989	Benicia	92,400	5.75
05/01/1989	Bennett's Marina	896,800	55.80
06/01/1989	Bennett's Marina	1,066,900	66.38
07/01/1989	Berkeley Marina	149,320	9.29
07/01/1989	Bennett's Marina	476,700	29.66
08/01/1989	Bennett's Marina	761,800	47.40
09/01/1989	Bennett's Marina	37,200	2.31
06/01/1990	Bennett's Marina	517,500	32.20
06/01/1990	Benicia	649,825	40.43
07/01/1990	Benicia	459,700	28.60
07/01/1990	Bennett's Marina	650,500	40.47
08/01/1990	Bennett's Marina	488,900	30.42
05/01/1991	Bennett's Marina	821,400	51.11
06/01/1991	Bennett's Marina	771,400	47.99
07/01/1991	Benicia	390,600	24.30
04/01/1992	Benicia	39,000	2.43
05/01/1992	Benicia	967,537	60.20
06/01/1992	Benicia	1,091,873	67.93
07/01/1992	Benicia	1,164,100	72.43
08/01/1992	Benicia	213,800	13.30
05/01/1994	Benicia	136,800	8.51
06/01/1994	Benicia	1,107,570	68.91
04/01/2001	Benicia	51,520	3.21
04/01/2001	Shore Terminal	1,464,200	91.10
05/01/2001	Shore Terminal	1,398,452	87.01
02/01/2002	Shore Terminal	1,160,079	72.18
05/01/2002	Monterey	140,500	8.74
05/01/2002	Shore Terminal	1,980,300	123.21
04/01/2003	Conoco Phillips	2,175,025	135.33
05/01/2003	Tiburon Net Pens	50,600	3.15
05/01/2003	Monterey	142,800	8.88
05/01/2004	Tiburon Net Pens	51,700	3.22
05/01/2004	Moss Landing	123,000	7.65

Untagged Mokelumne Hatchery Releases in the San Francisco Bay. Mean Rates of Return to the Tuolumne River = 0.00622%			
Release Date	Release Location	Number Released	Estimated Number of Adult Returns to the Tuolumne River
05/01/2004	Monterey	140,000	8.71
05/01/2004	Benicia	1,792,400	111.52
06/01/2004	Benicia	216,800	13.49

Untagged Merced River Hatchery Releases in the Merced River.
Mean Rates of Return to the Tuolumne River
Dry Years, spring releases = 0.00621%
Dry Years, fall releases = 0.00493%

Release Date	Release Location	Number Released	Estimated Number of Adult Returns to the Tuolumne River
10/14/1985	MRH	63,000	3.11
10/19/1987	MRH	254,842	12.57
04/18/1988	MRH	3,200	0.20
10/24/1988	MRH	1,000	0.05
10/06/1989	MRH	10,285	0.51
10/06/1989	MRH	41,184	2.03
10/06/1989	MRH	44,865	2.21
10/07/1989	MRH	36,673	1.81
10/07/1989	MRH	46,175	2.28
10/21/1991	Merced River	8,190	0.40
10/21/1991	Merced River	9,945	0.49
10/21/1991	Merced River	10,637	0.52
10/21/1991	Merced River	23,400	1.15
10/21/1991	Merced River	25,740	1.27
10/21/1991	Merced River	26,910	1.33
01/18/2001	Hagaman Park	1,000	0.06
01/18/2001	Hagaman Park	1,000	0.06
01/26/2001	Hagaman Park	1,010	0.06
01/31/2001	Gallo	507	0.03
01/31/2001	Gallo	633	0.04
02/01/2001	Hagaman Park	2,029	0.13
02/06/2001	Hagaman Park	1,070	0.07
03/01/2001	Gallo	810	0.05
03/07/2001	Hagaman Park	2,014	0.13
03/19/2001	Gallo	651	0.04
03/19/2001	Gallo	746	0.05
03/22/2001	Hagaman Park	2,016	0.13
03/29/2001	Hagaman Park	2,014	0.13
04/02/2001	Gallo	300	0.02
04/02/2001	Gallo	400	0.02
04/02/2001	Gallo	600	0.04
04/03/2001	Hagaman Park	24	0.00
04/06/2001	Hagaman Park	2,016	0.13
04/16/2001	Gallo	672	0.04

Untagged Merced River Hatchery Releases in the Merced River.
Mean Rates of Return to the Tuolumne River
Dry Years, spring releases = 0.00621%
Dry Years, fall releases = 0.00493%

Release Date	Release Location	Number Released	Estimated Number of Adult Returns to the Tuolumne River
04/16/2001	Gallo	708	0.04
04/16/2001	Gallo	717	0.04
04/16/2001	Robinson Ranch	3,043	0.19
04/18/2001	Hagaman Park	2,008	0.12
04/18/2001	Hagaman Park		0.00
04/22/2001	Gallo	702	0.04
04/22/2001	Gallo	718	0.04
04/22/2001	Gallo	784	0.05
04/22/2001	Robinson Ranch	3,150	0.20
04/25/2001	Gallo	327	0.02
04/25/2001	Gallo	462	0.03
04/26/2001	Hagaman Park	2,053	0.13
04/26/2001	Hagaman Park		0.00
04/27/2001	Gallo	375	0.02
05/02/2001	Hagaman Park	2,055	0.13
05/02/2001	Hagaman Park		0.00
05/04/2001	Gallo	360	0.02
05/04/2001	Gallo	487	0.03
05/09/2001	Gallo	711	0.04
05/09/2001	Gallo	738	0.05
05/09/2001	Robinson Ranch	3,021	0.19
05/10/2001	Hagaman Park	2,017	0.13
05/10/2001	Hagaman Park		0.00
05/11/2001	MRH	78,120	4.85
05/11/2001	MRH		0.00
05/11/2001	MRH	83,880	5.21
05/11/2001	MRH		0.00
05/14/2001	MRH	40,964	2.54
05/14/2001	MRH		0.00
05/14/2001	MRH		0.00
05/14/2001	MRH		0.00
05/16/2001	Hagaman Park	2,050	0.13
05/16/2001	Hagaman Park		0.00
05/21/2001	Gallo	802	0.05
05/21/2001	Gallo	806	0.05
05/21/2001	Gallo	807	0.05
05/21/2001	Robinson Ranch	3,249	0.20
05/24/2001	Hagaman Park	2,020	0.13
05/26/2001	Gallo	600	0.04
05/31/2001	Hagaman Park	1,618	0.10
02/07/2002	Hagaman Park	20	0.00
02/13/2002	Hagaman Park	1,859	0.12
02/20/2002	Gallo	687	0.04
02/23/2002	Gallo	1,268	0.08

Untagged Merced River Hatchery Releases in the Merced River.
Mean Rates of Return to the Tuolumne River
Dry Years, spring releases = 0.00621%
Dry Years, fall releases = 0.00493%

Release Date	Release Location	Number Released	Estimated Number of Adult Returns to the Tuolumne River
02/27/2002	Hagaman Park	2,224	0.14
03/06/2002	Gallo	764	0.05
03/06/2002	Hagaman Park	2,015	0.13
03/13/2002	Hagaman Park	2,075	0.13
03/19/2002	Gallo	1,881	0.12
03/20/2002	Hagaman Park	2,018	0.13
03/27/2002	Hagaman Park	2,068	0.13
03/30/2002	Hagaman Park	893	0.06
03/30/2002	Hagaman Park	1,130	0.07
04/02/2002	MRH	5,928	0.37
04/03/2002	Hagaman Park	2,042	0.13
04/04/2002	Gallo	2,067	0.13
04/04/2002	Robinson Ranch	3,050	0.19
04/10/2002	Hagaman Park	2,024	0.13
04/12/2002	Gallo	2,596	0.16
04/16/2002	MRH	7,100	0.44
04/17/2002	Hagaman Park	2,022	0.13
04/18/2002	Gallo	2,044	0.13
04/18/2002	Robinson Ranch	3,006	0.19
04/21/2002	Gallo	2,500	0.16
05/01/2002	MRH	7,019	0.44
05/01/2002	MRH	178,001	11.05
05/01/2002	MRH	183,140	11.37
05/02/2002	Hagaman Park	2,025	0.13
05/03/2002	Gallo	1,086	0.07
05/03/2002	Gallo	2,028	0.13
05/03/2002	Robinson Ranch	3,088	0.19
05/04/2002	Gallo	1,246	0.08
05/08/2002	Hagaman Park	2,116	0.13
05/14/2002	Hagaman Park	2,014	0.13
05/15/2002	MRH	7,149	0.44
05/17/2002	Gallo	2,008	0.12
05/17/2002	Robinson Ranch	3,025	0.19
05/20/2002	Gallo	2,400	0.15
05/22/2002	Hagaman Park	2,077	0.13
05/29/2002	Hagaman Park	2,048	0.13
02/22/2003	Gallo	800	0.05
03/12/2003	Gallo	1,652	0.10
03/22/2003	MRH	17,400	1.08
03/26/2003	Gallo	20,500	1.27
04/02/2003	Hagaman Park	100	0.01
04/03/2003	Gallo	2,000	0.12
04/03/2003	MRH	20,800	1.29
04/03/2003	Robinson Ranch	3,000	0.19

Untagged Merced River Hatchery Releases in the Merced River.
Mean Rates of Return to the Tuolumne River
Dry Years, spring releases = 0.00621%
Dry Years, fall releases = 0.00493%

Release Date	Release Location	Number Released	Estimated Number of Adult Returns to the Tuolumne River
04/04/2003	MRH	19,800	1.23
04/05/2003	MRH	17,500	1.09
04/03/2003	MRH	29,900	1.86
04/03/2003	Shaffer Bridge	21,375	1.33
04/06/2003	Shaffer Bridge	26,250	1.63
04/08/2003	Hagaman Park	101	0.01
04/08/2003	Hagaman Park	2,000	0.12
04/13/2003	MRH	11,625	0.72
04/14/2003	MRH	10,000	0.62
04/15/2003	Hagaman Park	2,000	0.12
04/16/2003	Gallo	2,000	0.12
04/16/2003	Robinson Ranch	3,000	0.19
04/22/2003	Hagaman Park	2,040	0.13
04/23/2003	MRH	10,209	0.63
04/25/2003	Gallo	2,000	0.12
04/25/2003	Robinson Ranch	3,000	0.19
04/29/2003	Hagaman Park	2,016	0.13
04/30/2003	MRH	1,807	0.11
05/02/2003	Hagaman Park	2,021	0.13
05/05/2003	MRH	9,979	0.62
05/06/2003	Hagaman Park	2,015	0.13
05/07/2003	Gallo	2,185	0.14
05/07/2003	Robinson Ranch	3,000	0.19
05/12/2003	MRH	7,550	0.47
05/12/2003	MRH	35,550	2.21
05/13/2003	Hagaman Park	2,009	0.12
04/05/2004	MRH	10,200	0.63
04/07/2004	Gallo	2,000	0.12
04/07/2004	Robinson Ranch	3,000	0.19
04/19/2004	MRH	10,200	0.63
04/21/2004	Gallo	2,032	0.13
04/21/2004	Robinson Ranch	3,003	0.19
05/03/2004	MRH	10,200	0.63
05/05/2004	Gallo	2,010	0.12
05/05/2004	MRH	9,156	0.57
05/05/2004	MRH	29,547	1.83
05/05/2004	MRH	44,012	2.73
05/05/2004	MRH	82,715	5.13
05/05/2004	Robinson Ranch	3,027	0.19
05/17/2004	MRH	10,200	0.63
05/19/2004	Gallo	2,000	0.12
05/19/2004	MRH	11,402	0.71
05/19/2004	MRH	36,088	2.24
05/19/2004	MRH	47,490	2.95

Untagged Merced River Hatchery Releases in the Merced River.
Mean Rates of Return to the Tuolumne River
Dry Years, spring releases = 0.00621%
Dry Years, fall releases = 0.00493%

Release Date	Release Location	Number Released	Estimated Number of Adult Returns to the Tuolumne River
05/19/2004	Robinson Ranch	3,017	0.19

Untagged Merced River Hatchery Releases in the Merced River.
Mean Rates of Return to the Tuolumne River
Wet Years, spring releases = 0.03181%
Wet Years, fall releases = 0.00127%

Release Date	Release Location	Number Released	Estimated Number of Adult Returns to the Tuolumne River
06/21/1978	MRH	100,000	0.32
09/29/1978	MRH	195,000	2.48
10/17/1984	MRH	73,600	0.93
03/08/1986	MRH	15,876	0.05
03/14/1986	MRH	20,448	0.07
03/18/1986	MRH	88,830	0.28
03/20/1986	MRH	38,762	0.12
03/26/1986	MRH	14,544	0.05
04/03/1986	MRH	49,298	0.16
04/08/1986	MRH	12,760	0.04
05/30/1986	MRH	351,250	1.12
06/18/1986	MRH	24,960	0.08
04/14/1995	Shaffer Bridge	2,430	0.01
05/02/1995	MRH	138,000	0.44
05/03/1995	Hagaman Park	1,000	0.00
05/03/1995	MRH	74,800	0.24
05/10/1995	MRH	130,050	0.41
05/10/1995	MRH	146,400	0.47
05/10/1995	MRH	276,450	0.88
04/01/1998	Hagaman Park	1,500	0.00
04/06/1998	Hagaman Park	2,010	0.01
04/13/1998	Hagaman Park	2,000	0.01
04/20/1998	Hagaman Park	2,000	0.01
04/27/1998	Hagaman Park	2,008	0.01
05/04/1998	Hagaman Park	2,000	0.01
05/12/1998	Hagaman Park	2,001	0.01
05/13/1998	MRH	113,500	0.36
05/18/1998	MRH	113,450	0.36
05/19/1998	Hagaman Park	1,001	0.00
05/19/1998	Hagaman Park	2,006	0.01
05/27/1998	Hagaman Park	1,000	0.00
05/27/1998	Hagaman Park	2,000	0.01
05/27/1998	MRH	60,546	0.19
05/29/1998	MRH	107,900	0.34
05/31/1998	MRH	84,945	0.27

Untagged Merced River Hatchery Releases in the Merced River.
Mean Rates of Return to the Tuolumne River
Wet Years, spring releases = 0.03181%
Wet Years, fall releases = 0.00127%

Release Date	Release Location	Number Released	Estimated Number of Adult Returns to the Tuolumne River
06/03/1998	Hagaman Park	1,000	0.00
06/03/1998	Hagaman Park	2,004	0.01
06/08/1998	Hagaman Park	2,000	0.01
06/17/1998	Hagaman Park	150	0.00
06/17/1998	Hagaman Park	850	0.00
06/17/1998	Hagaman Park	2,037	0.01
06/24/1998	MRH	24,480	0.08
06/25/1998	Hagaman Park	20	0.00
03/04/1999	Hagaman Park	1,005	0.00
03/17/1999	Hagaman Park	1,501	0.00
03/30/1999	Hagaman Park	2,000	0.01
04/06/1999	Hagaman Park	2,002	0.01
04/13/1999	Hagaman Park	2,007	0.01
04/21/1999	Gallo	421	0.00
04/21/1999	Gallo	442	0.00
04/21/1999	Hagaman Park	2,000	0.01
04/28/1999	Gallo	500	0.00
05/06/1999	Hagaman Park	2,008	0.01
05/11/1999	MRH	44,500	0.14
05/12/1999	Gallo	300	0.00
05/12/1999	Hagaman Park	2,000	0.01
05/17/1999	Robinson Ranch	5,000	0.02
05/18/1999	Gallo	500	0.00
05/18/1999	Gallo	501	0.00
05/18/1999	Hagaman Park	2,012	0.01
05/19/1999	Gallo	265	0.00
05/19/1999	Gallo	266	0.00
05/21/1999	Gallo	265	0.00
05/21/1999	Gallo	275	0.00
05/21/1999	Gallo	20,340	0.06
05/23/1999	Gallo	268	0.00
05/23/1999	Gallo	271	0.00
05/25/1999	Gallo	265	0.00
05/25/1999	Gallo	279	0.00
05/25/1999	Hagaman Park	1,000	0.00
05/25/1999	Hagaman Park	1,017	0.00
05/25/1999	Hagaman Park	1,024	0.00
05/27/1999	Hagaman Park	2,025	0.01
05/27/1999	Robinson Ranch	5,001	0.02
05/27/1999	Robinson Ranch	5,025	0.02
No Date	Robinson Ranch	5,001	0.02
No Date	Robinson Ranch	5,025	0.02
03/08/2000	Merced River	2,038	0.01
03/13/2000	Merced River	1,152	0.00

Untagged Merced River Hatchery Releases in the Merced River.
Mean Rates of Return to the Tuolumne River
Wet Years, spring releases = 0.03181%
Wet Years, fall releases = 0.00127%

Release Date	Release Location	Number Released	Estimated Number of Adult Returns to the Tuolumne River
03/14/2000	Merced River	346	0.00
03/14/2000	Merced River	360	0.00
03/15/2000	Hagaman Park	2,002	0.01
03/21/2000	Hagaman Park	2,000	0.01
03/28/2000	Hagaman Park	2,117	0.01
04/03/2000	Gallo	500	0.00
04/04/2000	Hagaman Park	2,028	0.01
04/05/2000	Robinson Ranch	2,001	0.01
04/12/2000	Gallo	2,038	0.01
04/13/2000	Hagaman Park	2,008	0.01
04/24/2000	Gallo	2,004	0.01
04/25/2000	Snelling	5,000	0.02
04/26/2000	Hagaman Park	2,000	0.01
04/29/2000	Gallo	509	0.00
05/12/2000	Gallo	393	0.00
05/12/2000	Gallo	503	0.00
05/14/2000	MRH	152,438	0.48
05/15/2000	Gallo	3,003	0.01
05/15/2000	Snelling	5,002	0.02
05/16/2000	Hagaman Park	2,026	0.01

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Appendix C.

Tuolumne Irrigation District
First Observed Dates of Adult Salmon near
LaGrange (1981-2004)

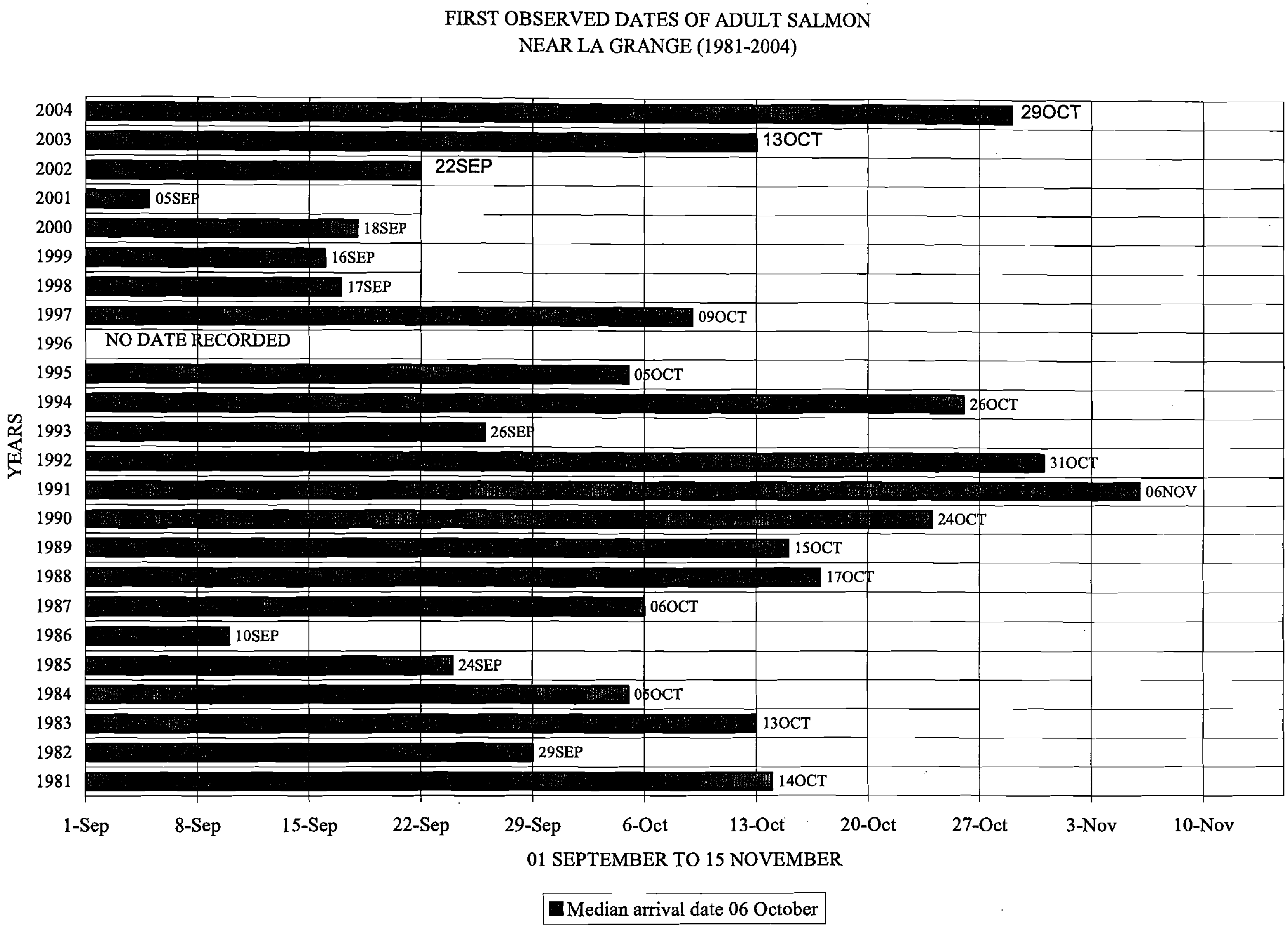

Figure 4. Tuolumne River salmon arrival near La Grange (1981-2004)

Appendix D.

Department of Water Resources Water Year Classification Indices

Department of Water Resources
California Data Exchange Center

WSIHIST (12/11/07 1223)

Department of Water Resources
California Cooperative Snow Surveys

Chronological Reconstructed Sacramento and San Joaquin Valley
Water Year Hydrologic Classification Indices

Based on measured unimpaired runoff (in million acre-feet), subject to revision.
*** See explanatory notes at bottom ***

	[..........Sacramento Valley..........]					[.........San Joaquin Valley..........]				
	[.....Runoff (maf).....]			[..WY Index..]		[.....Runoff (maf).....]			[..WY Index..]	
WY	Oct-Mar	Apr-Jul	WYsum	Index	Yr-type	Oct-Mar	Apr-Jul	WYsum	Index	Yr-type
1901						3.49	5.58	9.39	4.60	W
1902						1.12	3.81	5.08	3.41	AN
1903						1.45	4.13	5.71	3.45	AN
1904						1.96	5.37	7.64	4.31	W
1905						1.82	3.36	5.30	3.24	AN
1906	12.57	12.92	26.71	11.76	W	2.53	9.24	12.43	6.70	W
1907	18.96	13.45	33.70	14.07	W	3.67	7.61	11.82	6.20	W
1908	8.29	5.60	14.77	7.73	BN	0.98	2.17	3.32	2.40	D
1909	20.61	8.98	30.68	12.10	W	2.85	5.91	8.97	4.59	W
1910	13.12	6.11	20.12	9.38	W	2.87	3.62	6.64	3.65	AN
1911	12.27	13.12	26.38	11.74	W	3.63	7.52	11.48	5.97	W
1912	4.84	5.65	11.41	6.71	BN	0.54	2.57	3.21	2.55	BN
1913	5.72	6.29	12.85	6.24	D	0.44	2.34	3.00	2.00	C
1914	16.72	10.08	27.81	10.92	W	2.72	5.67	8.69	4.35	W
1915	11.41	11.42	23.86	10.99	W	1.29	4.95	6.40	4.10	W
1916	14.25	8.89	24.14	10.83	W	2.67	5.50	8.38	4.65	W
1917	7.25	9.14	17.26	8.83	AN	1.66	4.84	6.66	4.13	W
1918	5.27	4.89	10.99	6.19	D	1.07	3.40	4.59	3.08	BN
1919	8.12	6.77	15.66	7.00	BN	1.06	2.99	4.09	2.62	BN
1920	3.63	4.91	9.20	5.15	C	0.72	3.29	4.09	2.64	BN
1921	15.47	7.52	23.80	9.20	AN	1.97	3.84	5.90	3.23	AN
1922	6.63	10.57	17.98	8.97	AN	1.51	5.99	7.68	4.54	W
1923	6.21	6.27	13.21	7.06	BN	1.39	3.95	5.51	3.55	AN
1924	3.27	1.94	5.74	3.87	C	0.45	1.03	1.50	1.42	C
1925	8.76	6.51	15.99	6.39	D	1.45	3.93	5.51	2.93	BN
1926	6.37	4.79	11.76	5.75	D	0.89	2.56	3.49	2.30	D
1927	14.34	8.75	23.83	9.52	W	1.80	4.56	6.50	3.56	AN
1928	10.24	5.86	16.76	8.27	AN	1.69	2.64	4.37	2.63	BN
1929	4.00	3.84	8.40	5.22	C	0.52	2.29	2.84	2.00	C
1930	8.24	4.65	13.52	5.90	D	0.76	2.44	3.25	2.02	C
1931	3.52	2.09	6.10	3.66	C	0.46	1.18	1.66	1.20	C
1932	6.28	6.24	13.12	5.48	D	1.79	4.69	6.63	3.41	AN
1933	3.73	4.66	8.94	4.63	C	0.49	2.77	3.34	2.44	D
1934	5.68	2.45	8.63	4.07	C	0.98	1.26	2.28	1.44	C
1935	6.27	9.69	16.59	6.98	BN	1.26	5.03	6.41	3.56	AN
1936	10.32	6.41	17.35	7.75	BN	2.00	4.38	6.49	3.74	AN
1937	5.50	7.24	13.33	6.87	BN	1.78	4.66	6.53	3.90	W
1938	17.96	12.93	31.83	12.62	W	3.58	7.33	11.24	5.89	W
1939	4.56	3.04	8.18	5.58	D	1.00	1.83	2.90	2.20	D
1940	14.78	6.93	22.43	8.88	AN	2.49	4.04	6.59	3.36	AN
1941	16.32	9.77	27.08	11.47	W	2.22	5.51	7.93	4.43	W
1942	14.33	9.93	25.24	11.27	W	1.93	5.28	7.38	4.44	W
1943	13.37	6.90	21.13	9.77	W	2.86	4.28	7.28	4.03	W
1944	4.81	4.93	10.43	6.35	D	0.87	2.97	3.92	2.76	BN
1945	8.42	5.92	15.06	6.80	BN	2.07	4.37	6.60	3.59	AN
1946	10.89	5.97	17.62	7.70	BN	1.99	3.65	5.73	3.30	AN
1947	5.90	3.83	10.39	5.61	D	1.26	2.12	3.42	2.18	D
1948	5.39	9.55	15.75	7.12	BN	0.56	3.58	4.21	2.70	BN
1949	5.73	5.59	11.97	6.09	D	0.62	3.12	3.79	2.53	BN

1950	7.01	6.72	14.44	6.62	BN	1.02	3.57	4.65	2.85	BN
1951	16.77	5.42	22.95	9.18	AN	4.35	2.83	7.25	3.14	AN
1952	13.86	13.68	28.60	12.38	W	2.18	6.84	9.30	5.17	W
1953	10.84	8.26	20.09	9.55	W	1.07	3.18	4.35	3.03	BN
1954	9.74	6.81	17.43	8.51	AN	1.10	3.16	4.30	2.72	BN
1955	5.19	5.07	10.98	6.14	D	0.78	2.67	3.50	2.30	D
1956	20.32	8.60	29.89	11.38	W	4.14	5.29	9.67	4.46	W
1957	7.72	6.29	14.89	7.83	AN	1.02	3.19	4.29	3.01	BN
1958	16.37	12.24	29.71	12.16	W	1.67	6.40	8.36	4.77	W
1959	7.40	3.84	12.05	6.75	BN	0.98	1.85	2.98	2.21	D
1960	7.72	4.65	13.06	6.20	D	0.85	2.07	2.96	1.85	C
1961	6.87	4.39	11.97	5.68	D	0.54	1.50	2.10	1.38	C
1962	8.17	6.23	15.11	6.65	BN	1.26	4.24	5.61	3.07	BN
1963	12.01	10.09	22.99	9.63	W	1.68	4.37	6.24	3.57	AN
1964	5.90	4.37	10.92	6.41	D	0.93	2.14	3.14	2.19	D
1965	16.59	8.13	25.64	10.15	W	3.20	4.55	8.13	3.81	W
1966	7.42	4.84	12.95	7.16	BN	1.49	2.42	3.98	2.51	BN
1967	12.14	11.01	24.06	10.20	W	2.46	7.09	9.98	5.25	W
1968	8.66	4.12	13.64	7.24	BN	1.02	1.85	2.94	2.21	D
1969	15.33	10.68	26.98	11.05	W	3.84	8.14	12.29	6.09	W
1970	18.87	4.35	24.06	10.40	W	2.55	2.96	5.61	3.18	AN
1971	12.71	8.90	22.57	10.37	W	1.56	3.23	4.91	2.89	BN
1972	7.61	5.02	13.43	7.29	BN	1.25	2.22	3.57	2.16	D
1973	12.80	6.38	20.05	8.58	AN	1.87	4.48	6.47	3.50	AN
1974	21.69	9.78	32.50	12.99	W	2.43	4.53	7.12	3.90	W
1975	9.24	8.95	19.23	9.35	W	1.37	4.65	6.18	3.85	W
1976	4.63	2.75	8.20	5.29	C	0.78	1.07	1.97	1.57	C
1977	2.49	1.93	5.12	3.11	C	0.22	0.80	1.05	0.84	C
1978	14.90	8.12	23.92	8.65	AN	2.57	6.50	9.65	4.58	W
1979	6.06	5.64	12.41	6.67	BN	1.87	3.99	5.98	3.67	AN
1980	15.49	6.00	22.33	9.04	AN	3.74	5.41	9.47	4.73	W
1981	6.81	3.63	11.10	6.21	D	0.85	2.29	3.22	2.44	D
1982	20.56	11.82	33.41	12.76	W	3.78	7.00	11.41	5.45	W
1983	22.75	13.66	37.68	15.29	W	5.42	8.73	15.01	7.22	W
1984	15.98	5.52	22.35	10.00	W	3.51	3.48	7.13	3.69	AN
1985	6.24	4.00	11.04	6.47	D	1.11	2.41	3.60	2.40	D
1986	19.45	5.45	25.83	9.96	W	4.36	4.92	9.50	4.31	W
1987	5.85	2.80	9.27	5.86	D	0.55	1.48	2.08	1.86	C
1988	5.78	2.90	9.23	4.65	C	0.86	1.55	2.48	1.48	C
1989	9.03	5.07	14.82	6.13	D	1.07	2.42	3.56	1.96	C
1990	4.94	3.72	9.26	4.81	C	0.83	1.59	2.46	1.51	C
1991	3.90	4.01	8.44	4.21	C	0.56	2.57	3.20	1.96	C
1992	5.41	2.93	8.87	4.06	C	0.86	1.66	2.58	1.56	C
1993	12.44	8.98	22.21	8.54	AN	2.49	5.65	8.38	4.20	W
1994	4.55	2.73	7.81	5.02	C	0.66	1.80	2.54	2.05	C
1995	19.83	13.60	34.55	12.89	W	3.67	8.01	12.32	5.95	W
1996	13.05	8.37	22.29	10.26	W	2.57	4.51	7.22	4.12	W
1997	20.22	4.39	25.42	10.82	W	5.75	3.59	9.51	4.13	W
1998	17.65	12.54	31.40	13.31	W	2.82	7.11	10.43	5.65	W
1999	12.97	7.26	21.19	9.80	W	1.90	3.85	5.91	3.59	AN
2000	12.06	5.96	18.90	8.94	AN	1.98	3.78	5.90	3.38	AN
2001	5.64	3.46	9.81	5.76	D	0.92	2.23	3.18	2.20	D
2002	9.32	4.57	14.60	6.35	D	1.27	2.75	4.06	2.34	D
2003	10.71	7.74	19.31	8.21	AN	1.25	3.49	4.87	2.81	BN
2004	10.95	4.40	16.04	7.51	BN	1.51	2.25	3.81	2.21	D
2005	8.40	9.28	18.55	8.49	AN	2.73	6.28	9.21	4.75	W
2006	18.04	12.93	31.88	13.13	W	2.87	7.37	10.45	5.90	W
2007	6.56	3.02	10.25	6.17	D	0.98	1.44	2.46	1.96	C
min	2.49	1.93	5.12	3.11		0.22	0.80	1.05	0.84	
mean	11.27	6.52	18.62	8.33		1.97	3.81	5.96	3.29	
max	22.75	13.68	37.68	15.29		5.75	9.24	15.01	7.22	

1956-2005 mean

Eight River Index
River Runoff [maf]

WY	Dec	Jan	Feb	Mar	Apr	May

1901						
1902						
1903						
1904						
1905						
1906	0.55	3.69	2.93	7.00	5.34	6.43
1907	2.14	2.83	6.01	10.40	7.32	5.86
1908	1.43	2.27	2.12	2.19	2.53	2.59
1909	0.66	11.14	6.85	3.71	4.22	4.78
1910	3.09	2.90	2.55	4.84	4.21	3.30
1911	1.15	4.11	3.61	5.88	6.36	5.71
1912	0.55	1.20	0.94	1.61	1.58	3.33
1913	0.77	1.60	1.01	1.32	2.81	3.31
1914	1.72	8.50	3.99	4.18	5.05	5.28
1915	0.76	1.86	5.43	3.54	4.43	6.38
1916	1.52	3.75	4.89	5.71	5.03	4.44
1917	1.28	1.01	3.13	2.15	4.29	4.37
1918	0.70	0.57	1.22	2.99	3.09	2.53
1919	0.68	1.20	3.13	2.74	3.89	4.06
1920	0.68	0.57	0.58	1.71	2.58	3.20
1921	2.90	4.34	3.15	4.22	3.30	4.01
1922	1.16	1.07	2.63	2.41	3.66	6.68
1923	2.03	1.75	1.20	1.51	3.38	3.66
1924	0.49	0.56	1.16	0.64	1.07	1.10
1925	0.92	0.94	4.99	2.18	3.82	3.70
1926	0.67	0.76	3.18	1.73	3.79	2.18
1927	2.01	2.22	6.05	3.53	4.82	4.28
1928	1.10	1.37	1.94	5.69	3.73	3.02
1929	0.64	0.61	1.12	1.29	1.63	2.49
1930	2.37	1.41	1.84	2.78	2.64	2.29
1931	0.39	0.80	0.78	1.20	1.23	1.18
1932	1.68	1.33	1.84	2.50	2.73	4.16
1933	0.42	0.70	0.58	1.89	1.97	2.36
1934	1.04	1.47	1.59	1.90	1.61	1.09
1935	0.79	1.87	1.56	2.13	6.18	4.74
1936	0.51	3.22	5.04	2.77	3.83	3.71
1937	0.45	0.54	2.36	3.28	3.77	4.92
1938	4.81	1.86	5.27	7.50	5.98	7.34
1939	0.80	0.79	0.81	1.91	2.26	1.47
1940	0.68	3.88	5.68	6.22	4.61	3.77
1941	3.41	4.28	5.07	4.72	4.62	5.75
1942	3.58	4.18	5.10	2.23	4.64	4.76
1943	1.83	4.67	2.84	5.33	4.23	3.59
1944	0.55	0.78	1.44	1.94	1.88	3.34
1945	1.50	1.07	4.13	2.17	2.82	3.82
1946	4.60	2.64	1.31	2.29	3.45	3.68
1947	1.06	0.64	1.57	2.51	2.20	2.05
1948	0.50	1.91	0.70	1.56	4.34	4.51
1949	0.66	0.53	0.92	3.32	3.27	3.39
1950	0.43	1.82	2.54	2.46	3.74	3.73
1951	5.95	3.40	3.52	2.66	2.81	3.15
1952	3.36	3.48	4.03	3.68	6.35	7.51
1953	1.92	5.40	1.52	2.06	3.25	3.38
1954	0.80	2.20	2.84	3.66	4.56	3.27
1955	1.35	1.16	0.96	1.27	1.97	3.22
1956	9.14	7.52	3.71	3.07	3.51	5.24
1957	0.61	0.79	2.65	3.41	2.36	3.85
1958	1.62	2.39	7.61	4.71	6.04	6.74
1959	0.58	2.25	2.50	1.98	2.27	1.82
1960	0.47	0.90	3.15	3.22	2.50	2.39
1961	1.36	0.86	2.14	1.93	2.02	2.16
1962	1.19	0.78	4.08	2.39	3.89	3.14
1963	1.90	1.70	4.66	2.10	5.60	4.99
1964	0.85	1.55	1.01	1.15	1.92	2.44
1965	8.66	5.61	2.26	1.97	4.74	3.81
1966	1.04	1.85	1.56	2.52	3.33	2.52
1967	2.98	3.34	2.52	4.09	3.82	6.26
1968	0.85	1.49	3.71	2.55	2.17	2.15
1969	1.77	7.91	4.73	3.36	5.44	7.34

1970	3.30	10.68	3.02	3.12	1.82	2.77
1971	3.26	3.05	1.83	3.73	3.40	4.18
1972	1.19	1.40	1.73	3.30	2.52	2.61
1973	1.83	4.08	3.66	3.27	3.08	4.76
1974	3.68	6.93	2.10	6.18	5.07	4.69
1975	0.86	1.01	2.92	4.65	2.89	5.40
1976	0.76	0.65	0.88	1.34	1.35	1.44
1977	0.38	0.47	0.48	0.54	0.69	0.91
1978	1.90	5.91	3.48	5.36	4.40	4.70
1979	0.53	1.44	2.10	2.90	2.67	4.50
1980	1.24	6.89	5.93	3.62	3.11	3.67
1981	0.92	1.57	1.76	2.48	2.32	2.11
1982	5.58	3.50	5.57	4.74	8.05	5.68
1983	3.69	4.25	6.46	10.57	4.87	6.96
1984	6.72	2.85	2.29	3.08	2.50	3.60
1985	1.20	0.84	1.21	1.59	2.79	2.14
1986	1.25	2.62	11.55	7.09	3.19	3.56
1987	0.53	0.78	1.48	2.60	1.73	1.48
1988	1.70	1.84	1.01	1.26	1.48	1.59
1989	0.72	0.85	0.99	6.17	3.59	2.22
1990	0.45	1.27	0.88	1.84	1.80	1.77
1991	0.34	0.37	0.45	2.64	1.95	2.40
1992	0.47	0.58	2.41	1.99	2.17	1.33
1993	1.25	4.06	3.13	5.70	4.33	5.23
1994	0.78	0.78	1.23	1.49	1.57	1.79
1995	1.06	8.11	3.12	10.19	5.61	7.18
1996	1.72	2.47	6.25	4.25	3.97	5.50
1997	6.84	12.15	2.74	2.45	2.70	2.96
1998	1.18	5.19	7.44	5.11	4.53	5.53
1999	1.88	2.60	4.59	3.67	3.26	4.27
2000	0.65	2.55	5.49	4.08	3.55	3.62
2001	0.67	0.87	1.50	2.39	2.03	2.49
2002	2.50	2.70	1.74	2.31	2.82	2.60
2003	3.24	3.40	1.66	2.52	3.27	4.82
2004	2.14	1.90	3.98	3.47	2.64	2.29
2005	1.56	2.49	2.01	3.75	3.18	7.23
2006	5.82	5.21	3.44	5.30	8.52	6.80
2007	1.31	0.85	2.14	2.06	1.73	1.66
min	0.34	0.37	0.45	0.54	0.69	0.91
mean	2.02	3.04	3.11	3.48	3.21	3.70
max	9.14	12.15	11.55	10.57	8.52	7.51

1956-2005 mean

Official Year Classifications based on May 1 Runoff Forecasts

	Sacramento Valley Index		San Joaquin Valley Index	
WY	Index	Yr-type	Index	Yr-type
1995	12.4	W	5.5	W
1996	9.7	W	3.9	W
1997	11.0	W	4.2	W
1998	12.4	W	4.9	W
1999	10.0	W	3.4	AN
2000	9.2	W	3.3	AN
2001	5.9	D	2.3	D
2002	6.5	D	2.3	D
2003	8.0	AN	2.7	BN
2004	7.7	BN	2.2	D
2005	7.4	BN	4.2	W
2006	13.0	W	5.5	W
2007	6.2	D	1.9	C

Abbreviations:

WY	Water year (Oct 1 - Sep 30)
W	Wet year type
AN	Above normal year type
BN	Below normal year type
D	Dry year type

```
C       Critical year type
% exc.  Probability in % that a given value will be exceeded
[maf]   Million acre-feet
```

Notes:

Unimpaired runoff represents the natural water production of a river basin, unaltered by upstream diversions, storage, export of water to or import of water from other basins.

Sacramento River Runoff is the sum (in maf) of Sacramento River at Bend Bridge, Feather River inflow to Lake Oroville, Yuba River at Smartville, and American River inflow to Folsom Lake. The WY sum is also known as the Sacramento River Index, and was previously referred to as the "4 River Index" or "4 Basin Index". It was previously used to determine year type classifications under State Water Resources Control Board (SWRCB) Decision 1485.

Sacramento Valley Water Year Index = 0.4 * Current Apr-Jul Runoff Forecast (in maf) + 0.3 * Current Oct-Mar Runoff in (maf) + 0.3 * Previous Water Year's Index (if the Previous Water Year's Index exceeds 10.0, then 10.0 is used). This index, originally specified in the 1995 SWRCB Water Quality Control Plan, is used to determine the Sacramento Valley water year type as implemented in SWRCB D-1641. Year types are set by first of month forecasts beginning in February. Final determination is based on the May 1 50% exceedence forecast.

Sacramento Valley Water Year Hydrologic Classification:

Year Type:	Water Year Index:
Wet	Equal to or greater than 9.2
Above Normal	Greater than 7.8, and less than 9.2
Below Normal	Greater than 6.5, and equal to or less than 7.8
Dry	Greater than 5.4, and equal to or less than 6.5
Critical	Equal to or less than 5.4

San Joaquin River Runoff is the sum of Stanislaus River inflow to New Melones Lake, Tuolumne River inflow to New Don Pedro Reservoir, Merced River inflow to Lake McClure, and San Joaquin River inflow to Millerton Lake (in maf).

San Joaquin Valley Water Year Index = 0.6 * Current Apr-Jul Runoff Forecast (in maf) + 0.2 * Current Oct-Mar Runoff in (maf) + 0.2 * Previous Water Year's Index (if the Previous Water Year's Index exceeds 4.5, then 4.5 is used). This index, originally specified in the 1995 SWRCB Water Quality Control Plan, is used to determine the San Joaquin Valley water year type as implemented in SWRCB D-1641. Year types are set by first of month forecasts beginning in February. Final determination for San Joaquin River flow objectives is based on the May 1 75% exceedence forecast.

San Joaquin Valley Water Year Hydrologic Classification:

Year Type:	Water Year Index:
Wet	Equal to or greater than 3.8
Above Normal	Greater than 3.1, and less than 3.8
Below Normal	Greater than 2.5, and equal to or less than 3.1
Dry	Greater than 2.1, and equal to or less than 2.5
Critical	Equal to or less than 2.1

Eight River Index = Sacramento River Runoff + San Joaquin River Runoff This Index is used from December through May to set flow objectives as implemented in SWRCB Decision 1641.

The 'reconstructed' table is based on observed runoff, and does NOT show the official year-types, which are based on May 1 forecasts of future runoff.

The current water year indices based on forecast runoff are posted at http://cdec.water.ca.gov/water_supply.html and published in DWR Bulletin 120 (also available at http://cdec.water.ca.gov/snow/bulletin120)

These indices have been used operationally since 1995, and are defined in SWRCB Decision 1641 (see http://www.waterrights.ca.gov/baydelta/d1641.htm)

This report is updated each fall once the data is available.

For more information, contact CDWR Flood Management, Hydrology Branch

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Report name: Get report

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Appendix E.

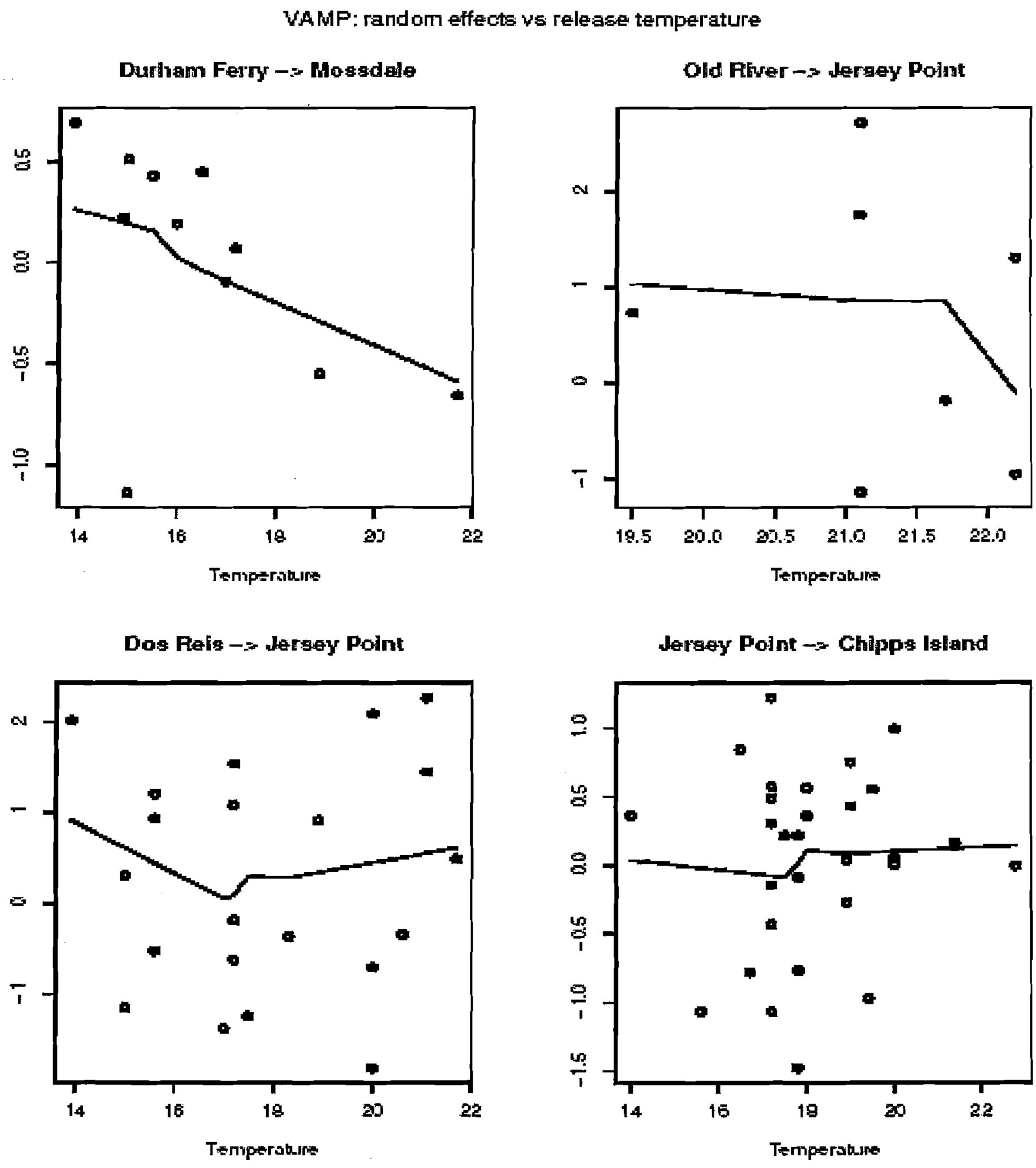
Newman (2008)
An evaluation of four Sacramento-San Joaquin River Delta juvenile salmon survival studies.

An evaluation of four Sacramento-San Joaquin River Delta juvenile salmon survival studies

Ken B. Newman[1]
Stockton FWO
US Fish and Wildlife Service

March 31, 2008

FIGURE 30. VAMP: Random effects residuals, by stream section, for logit of survival plotted against water temperature at release with supersmoother fit superimposed. The effects for Jersey Point are for the logit of Chipps Island recovery rate, either $r_{JP\rightarrow Ant\rightarrow CI}$ or $r_{JP\rightarrow CI}$. (Based on Null.FE.FE model.)



Appendix F.

Tuolumne River 2002 water temperature example.

Appendix F.

Tuolumne River 2002 water temperature example.

2002	Julian Week							
River Mile	36	37	38	39	40	41	42	43
52	12.1	12.3	12.6	12.1	11.9	12.1	11.9	11.7
47								
45.5								
43.4								
42	21.5	21.6	21.7	19.9	17.9	16.7	14.1	13.6
40.4								
36.7								
32	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
26								
23.6								
4								
3.4								
0.1								

Adult Migration/Egg Viability

Impaired Temperature = >18 Degrees C

Year	2002							
	Julian Week							
River Mile	36	37	38	39	40	41	42	43
52	12.1	12.3	12.6	12.1	11.9	12.1	11.9	11.7
51	13.0	13.2	13.5	12.9	12.5	12.5	12.1	11.9
50	13.9	14.2	14.4	13.7	13.1	13.0	12.4	12.1
49	14.9	15.1	15.3	14.5	13.7	13.4	12.6	12.3
48	15.8	16.0	16.2	15.2	14.3	13.9	12.8	12.5
47	16.8	17.0	17.1	16.0	14.9	14.4	13.0	12.7
46	17.7	17.9	18.1	16.8	15.5	14.8	13.2	12.9
45	18.7	18.8	19.0	17.5	16.1	15.3	13.5	13.0
44	19.6	19.8	19.9	18.3	16.7	15.8	13.7	13.2
43	20.5	20.7	20.8	19.1	17.3	16.2	13.9	13.4
42	21.5	21.6	21.7	19.9	17.9	16.7	14.1	13.6
41	21.8	21.9	22.0	20.1	18.0	16.9	14.3	13.7
40	22.1	22.2	22.2	20.4	18.2	17.2	14.5	13.8
39	22.3	22.4	22.5	20.7	18.4	17.4	14.6	14.0
38	22.6	22.7	22.8	20.9	18.6	17.6	14.8	14.1
37	22.9	22.9	23.0	21.2	18.8	17.9	15.0	14.2
36	23.2	23.2	23.3	21.5	19.0	18.1	15.2	14.3
35	23.5	23.5	23.6	21.7	19.2	18.4	15.3	14.4
34	23.8	23.7	23.8	22.0	19.4	18.6	15.5	14.5
33	24.0	24.0	24.1	22.3	19.6	18.8	15.7	14.6
32	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
31	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
30	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
29	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
28	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
27	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
26	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
25	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
24	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
23	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
22	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
21	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
20	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
19	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
18	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
17	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
16	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
15	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
14	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
13	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
12	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
11	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
10	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
9	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
8	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
7	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
6	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
5	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
4	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
3	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
2	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
1	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
0	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8

Empirical Data

Assumed Values

Summary	36	37	38	39	40	41	42	43
Average Reach 7DAM	24.3	24.2	24.4	22.5	19.8	19.1	15.9	14.8
Impaired Miles	46	46	47	45	42	37	0	0
Total Miles	52	52	52	52	52	52	52	52
Percent Impairment	88%	88%	90%	87%	81%	71%	0%	0%

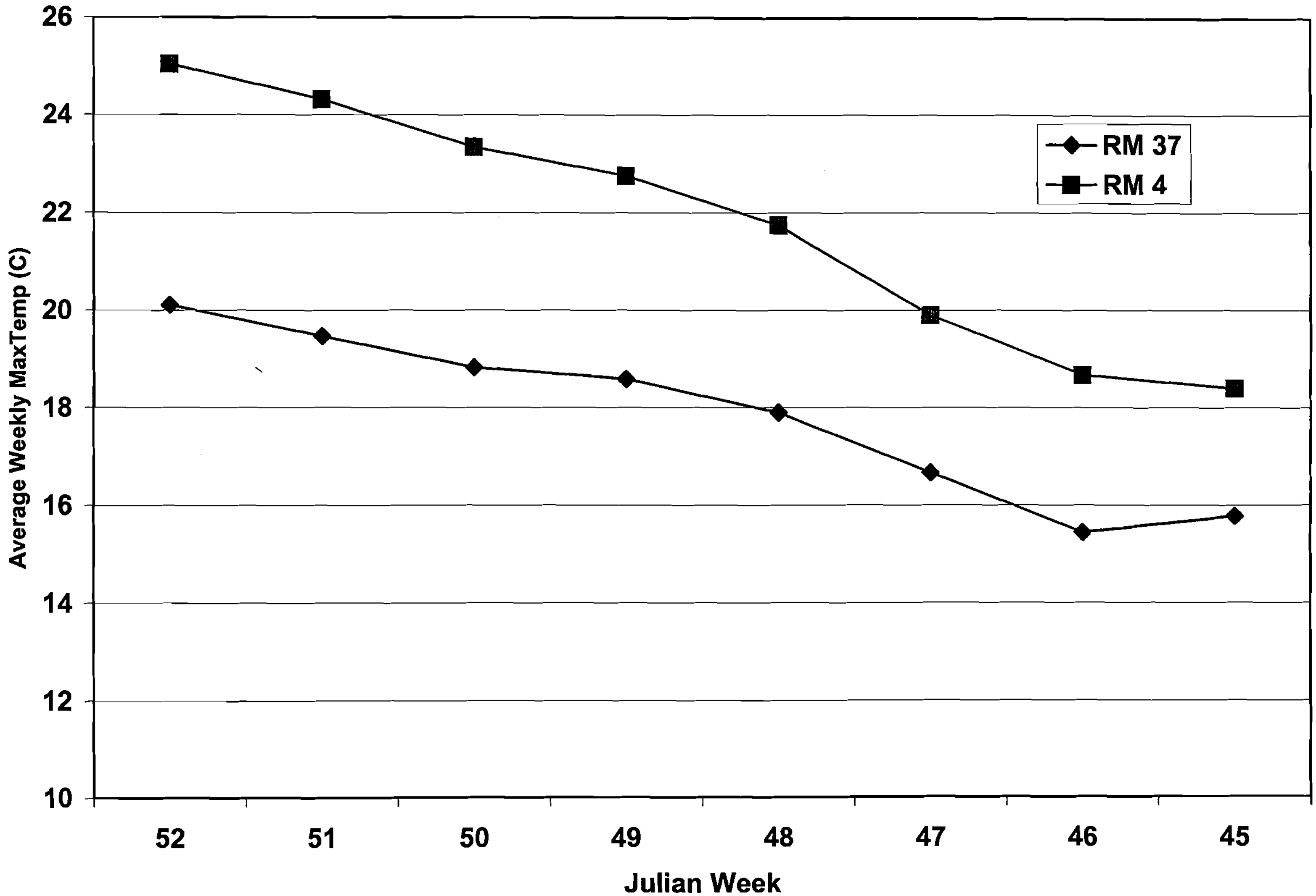
2002 Total Impairment

63%

Appendix G.

Water Temperature Warming in Tuolumne River 2003

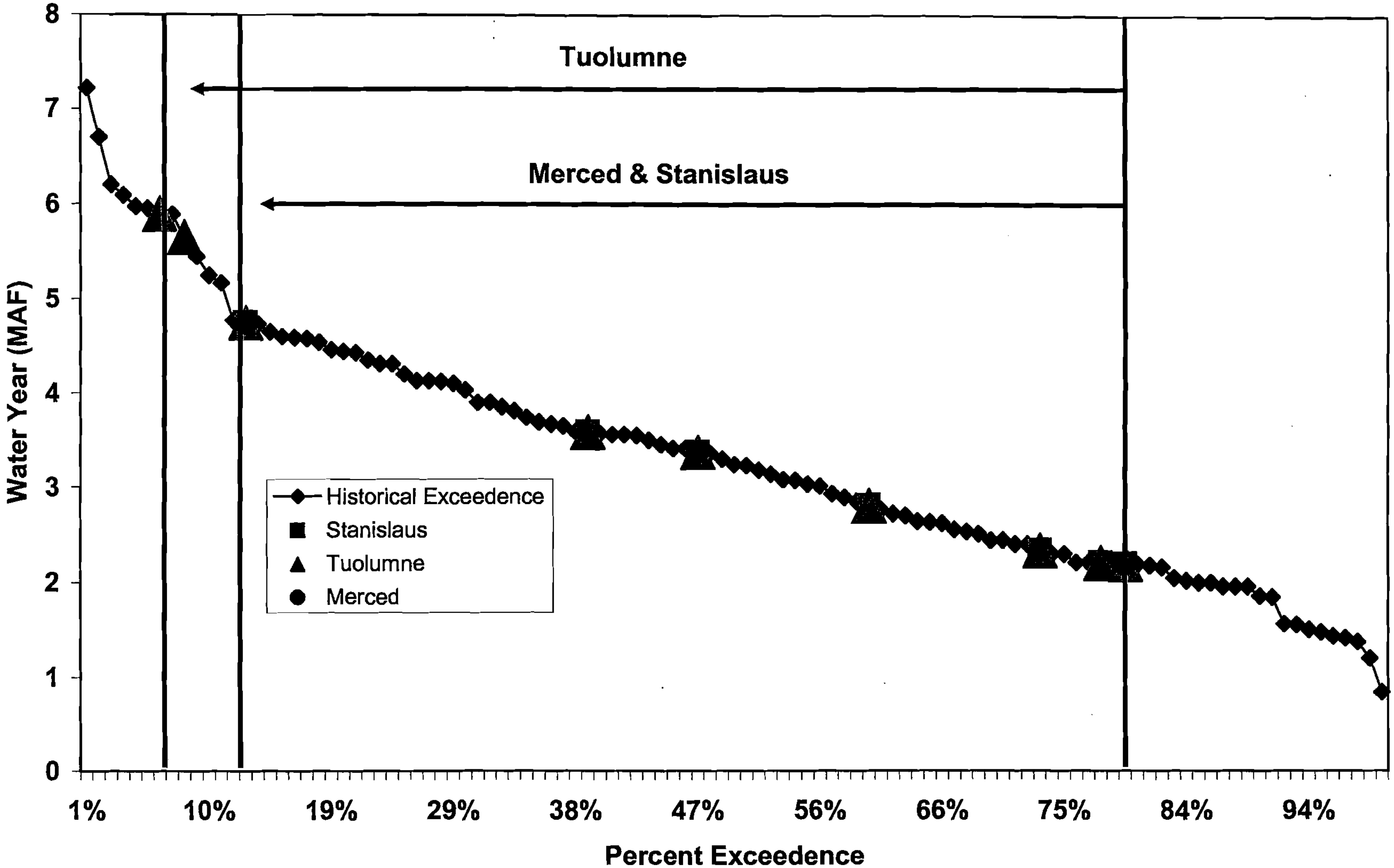
Water Temperature Warming in Tuolumne River 2003



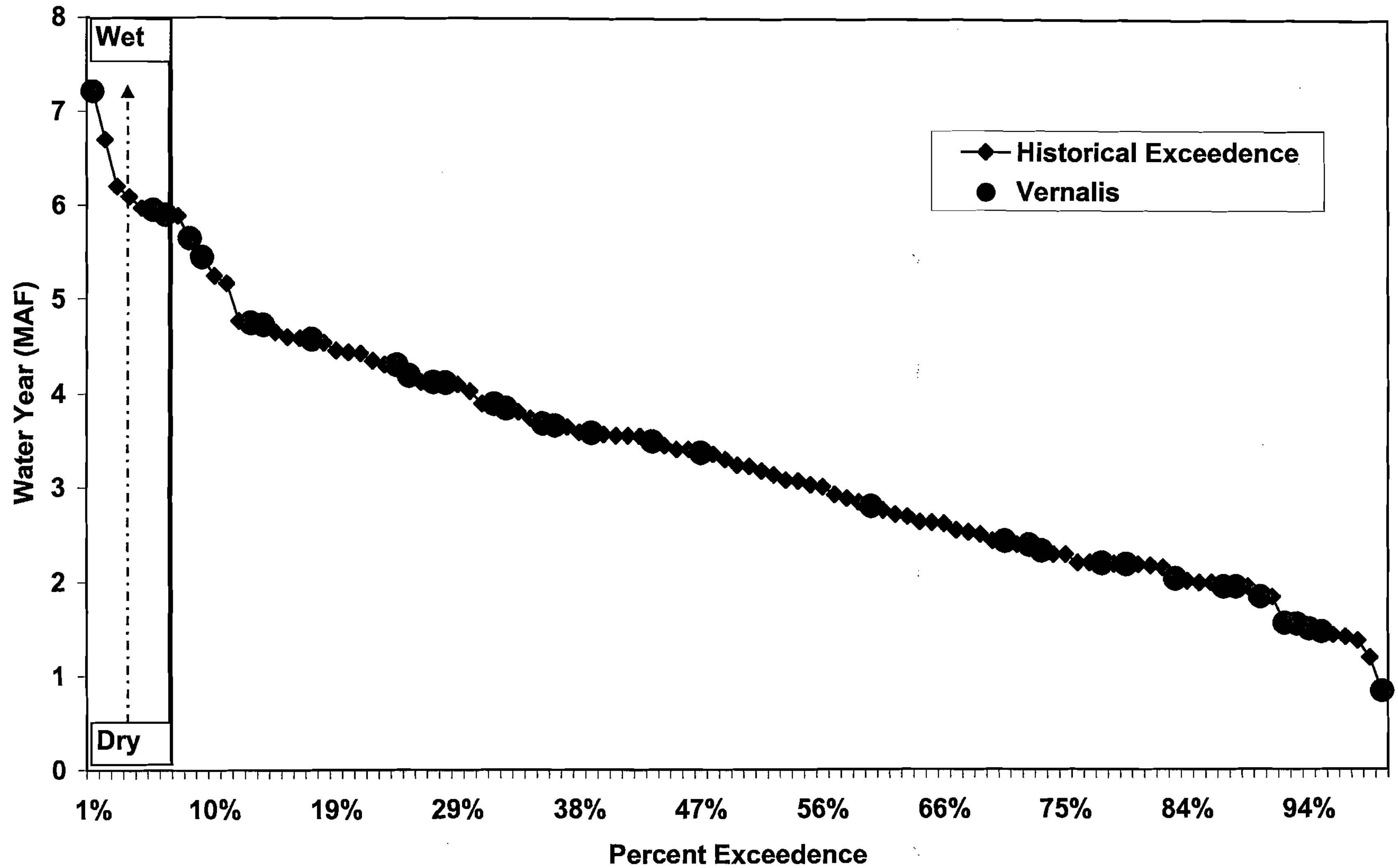
Appendix H.

San Joaquin Valley Hydrologic Classification (1901 thru 2007)
Tuolumne, Merced and Stanislaus Rivers

SJ Valley Hydrologic Classification (1901 thru 2007)



San Joaquin Valley Hydrologic Classification (1901 thru 2007)



Appendix J.

2003 Temperature vs. Redd Counts
Knights Ferry

2003 Temperature vs. Redd Counts
Knights Ferry